HISTORY AND CHARACTERISTICS OF MAN-MADE FILL IN BOSTON AND CAMBRIDGE

by

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Abstract

In the context of the study 'Liquefaction Risk Maps of the Boston Area' sponsored by the United States Geological Survey, it was necessary to characterize the natural and man-made geology. Since much of the Boston area consists of artifically filled land, this study exclusively treats this aspect of the local geology. The studied areas consist of Boston Peninsula, Back Bay, Back Bay Fens, Cambridge, Charlestown, East Boston, South Boston, South Cove and South Bay. A set of maps is developed for each of the areas mentioned above. In each set of maps, the oiginal shoreline, man-made topographical development and filled regions are drawn. The filled regions are shown in different shadings representing different characteristics.In the text detailed descriptions of filling operation and material characteristics are given.

Thesis Supervisor: Professor Herbert H. Einstein
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Dedication

To Dad and Mom.

Acknowledgement

The author acknowledges with gratitude to Professor Herbert H. Einstein for his valuable advice and suggestion during the course of this work. It has been a pleasure to work under his guidance.

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To my parents, who have always love and support me for all these years.

To God be the glory!

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Chapter 1

Introduction

This report is concerned with landfill in the Boston area. It is one of the reports for the project 'Liquefaction Risk Map of the Boston Area', sponsored by the United States Geological Survey (USGS) under grant number 14-08-00010G1188. The purpose of this report is to study the characteristics of artificial surface deposits so that its liquefaction susceptibility can be determined[1]. Liquefaction susceptibility is a measure of the relative likelihood of the deposits/soils to liquefy during earthquake. Several charateristics of artificial deposits may affect the liquefaction susceptibility:

(a) the type of filling material and its source

(b) the mode of handling - including excavation, transportation and deposition

(c) the age

Boston has a long landfill history. The earliest landfilling started shortly after colonization and major landfilling began in the early nineteenth century with reclamation of land around the Boston Peninsula. As time passed, more land was filled at different locations such that today more than one third of the surface area of Boston and Cambridge consists of artificially filled lands.

Filling material was obtained from many different sources. The main sources

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[1] A parallel report by M. Hawkes entitled 'Surficial Geology of the Boston Basin, MA.' deals with the geology history and characteristics of natural deposits in the Boston area.

were the hills such as Beacon Hill and Bunker Hill providing sand and gravel, the Charles River providing silt and mud, the harbor surrounding South and East Boston providing mud and clay and quarries outside of Boston providing sand and gravel. These and the other materials used will be discussed in detail in the subsequent chapters.

Usually, material from hills or quarries was transported by rail and dumped directly at the site. Material from water was handled by scows in the early years; but after the invention of the hydraulic dredge, the material was pumped to the site. The mode of handling influences the degree of compaction of filling material which affects liquefaction susceptibility. The combination of various filling materials and different handling processes yields artificial deposits with widely varying characteristics.

The studied areas are the Boston Peninsula, Back Bay, Back Bay Fens, Cambridge, Charlestown, East Boston, South Boston, South Cove and South Bay. Each area is discussed in a separate chapter with a specific set of maps The first map in each chapter is a current map of the area and serves as a base map on which sequential maps can be overlayed. Sequential maps in the same chapter show the original shoreline, man-made topographical development and particularly filled lands. All the maps are in the scale 1:5000. Filled lands are shown in different shadings. Each filled land is designated by a code composed of a prefix and a number. Table 1 contains a list of the prefixes.

Table 1 - List of most Prefixes used to Designated Filled Areas

EC - East Cove of Boston Peninsula

NC - North Cove of Boston Peninsula

WC - West Cove of Boston Peninsula

BB - Back Bay

F - Back Bay Fens

C - Cambridge

CT - Charlestown

EB - East Boston

SB - South Boston

SC - South Cove

SBY- South Bay

The written discussion in each chapter provides details on the fill history and characteristics. The grade levels appeared in subsequent chapters are using mean low water line as reference line unless specified otherwise. The mean low water line is 4.84 feet below the USCAGS Mean Sea Level Datum of 1929 and is 0.81 feet above the Boston City Base. Literature references are listed at the end of each chapter and map references are provided at the end of this report.

Chapter 2

Boston Peninsula

2.1 Introduction

The Boston Peninsula was connected to the mainland by a very narrow neck which is today's Washington Street. The peninsula originally had a surface area of less than five hundred acres. The old shoreline of the peninsula was characterized by several coves: West, North, East and South (see Map 2.2). In this chapter, the first three coves are discussed while South Cove will be treated in detail together with South Bay in Chapter 9. The coves were probably formed by the wearing away of land by the surrounding sea. Marshes were found in several locations along the shore (see Map 2.2).

Hills were another major topographical feature on the peninsula. The major ones were Copp's - which rose to a height of fifty feet, Fort - of a height of eighty feet and Trimountain which consisted of Mt. Vernon on the west, Beacon at the center and Pemberton on the east (see Map 2.2). Beacon Hill was the biggest of all and rose to a height of one hundred and thirty-eight feet above sea level. All these hills with the exception of Trimountain/Beacon Hill are thought to be drumlins; Beacon Hill has been catergorized by Kaye (1976) as a late glacial readvance end moraine. In addition, a small hill named Fox Hill, located in today's Boston Common (see Map 2.2), was frequently mentioned in the early records.

2.2 West Cove

West Cove had a surface area of about eighty acres and consisted of marsh at its shore. The cove was located at the foot of Mt. Vernon. Filling began at about 1804, material was cut from Mt. Vernon. A railroad was built to transport the fill material down to the foot of the hill and to dump it into the water. When filling was finished, Charles Street was laid out. This area is marked 'WC1' (see Map 2.4). It is believed that Fox Hill was levelled because of its vicinity to Charles Street. Material from Fox Hill was probably used to fill Charles Street. The land west of Charles Street was filled with other materials under different projects (for details, see Chapter 3, Back Bay, areas 'BB1' and 'BB4B').

2.3 North Cove

North Cove lay between Trimountain and Copp's Hill. Development of the cove started with the construction of a mill dam/causeway (see Map 2.3) in the 1640's. The causeway crossed the cove in an east west direction and allowed traffic of horses and carts. The causeway was approximately located along today's Causeway Street. The enclosed mill pond had a surface area of about seventy acres. The pond was connected to East Cove through mill creek(see Map 2.3) which was approximately located along today's Blackstone Street. The creek was excavated at the same time as the causeway was built. It provided an inlet for tidal water which generated power for the operation of mills.

In 1805, filling of the mill pond (area 'NC1' in Map 2.4) was started. Material

was mainly obtained from Beacon Hill and partly from Copp's Hill. Gravel from Beacon Hill was dug by hand and transported by two wheeled tipcarts pulled by horses. In addition, oyster shells, rubbish and street sweepings were dumped into the pond for many years. The filling process lasted for about twenty years and was finished in 1824.

In the early filling stage of mill pond, mill creek was upgraded into a canal. It started from the causeway and entered into the East Cove (see Map 2.3). The bottom was excavated to allow navigation. Both sides of the canal were lined with granite blocks. It was not used for a long time and in 1833 the canal was filled. No informaton was found on how it was filled but it is believed that the canal was filled with the same material used for the mill pond.

The area north of the causeway (area 'NC2' in Map 2.4) was filled in 1835. Gravel was obtained from Pemberton Hill. It was dug by hand and transported by rail down the hill. Oxen pulled carts were then used for hauling and dumping the gravel.

2.4 East Cove

East Cove, which lay between North End and Fort Hill, covered a surface area of about one hundred and ten acres. Marsh was found along its shore (see Map 2.2). It had a long history of development for it had been the shipping and trading center of Boston for a long time. In 1673, a wall made of wood and granite blocks called Old Wharfe was constructed across the cove from Fort Hill to North End (see

Map 2.2). It was used for defense against enemy attacks from the harbor. Remnants of this structure may survive and be buried beneath present streets and structures.

In the eighteenth century, a series of timber wharves were built along the waterfront (see Map 2.2). The most significant of these wharves was Long Wharf which was first constructed between 1710 and 1712. Numerous other wharves were constructed along the waterfront between Fort Hill and North End. Construction details are lacking, but it is likely that these wharves were built of timber planks, supported on timber piles driven into the Boston Blue Clay. The 1795 wharfline is shown in Map 2.2.

Another generation of wharves was constructed during the first half of nineteenth century. Typical ones were Rowe's, India, Central, Commercial and Lewis Wharves (see Map 2.3). Some other smaller wharves continued along the shoreline to North Cove. Long Wharf was rebuilt with a 'T' projection named T Wharf on its side. Commercial Street and the area bounded by it (area 'EC1' in Map 2.4) was filled in between 1827 and 1829 (Surveying Department, 1894) but no further information on the filling process was recorded in the document. The big wharves usually had granite walls on their boundaries. These walls were either sunk into the hard bottom if present or supported on piles. Additional piles were driven along the walls as reinforcements. Fill was placed between the walls and around the eighteenth century wharves. Since wharf construction was done by private companies under different projects on a comparatively small scale, it is very hard to trace back detailed information on how the wharves were constructed and filled. A

possible source of filling material was from the hills on the Boston peninsula. The small wharves around the North End which were also constructed during this period were probably built on piles similar to thoseofn the eighteenth century. The 1850 wharfline is shown in Map 2.3.

Atlantic Avenue (area 'EC2' in Map 2.4) was filled and laid out between 1868 and 1872. The avenue ran across East Cove through many wharves and it is located at about the site of the Old Wharfe erected in 1673. Filling material was excavated from Fort Hill by steam shovels, then transported by an elevated railroad down the hill and dumped along the adjacent shore front. The same material was used to fill areas between wharves. The hill was levelled when filling was completed.

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Chapter 3

Back Bay

3.1 Introduction

Back Bay is defined as the area bounded by the Charles River to the north, Charles Street on the east, original shoreline to the south and part of the west and Massachusetts Avenue to the remaining west (see Map 3.3). Its surface area is about 570 acres. Before Back Bay was filled, it was a large area of marshy flats with channels ior river flow (see Map 3.2). Filling began in the early nineteenth century when ashes and refuses were dumped along the shoreline. From the mid to the end of nineteenth century, a big project was undertaken to fill a large portion of the bay with sand and gravel. The last filled land, 1929 to 1931, was Storrow Drive using material dredged from the Charles River.

3.2 Dams and Railroad Embankments

The first modification of the bay was the construction of Mill Dam and Cross Dam (see Map 3.2) between 1818 to 1821. The Mill Dam was fifty feet wide and one and a half mile long, carrying a toll road, which ran along the line of present Beacon Street from Charles Street to the junction of Brookline and Commonwealth Avenues at Kenmore Square. Cross Dam was built to the east of the present Massachusetts Avenue and it connected the Mill Dam with Gravelly Point. East of the Cross Dam was the Receiving Basin (i.e. now the Back Bay) and west of it was

the Full Basin (i.e. now developed as the Back Bay Fens which will be discussed in more detail in Chapter 4, Back Bay Fens). Mill sites were located near to Cross Dam. At high tide, water was admitted to the Full Basin; the water then passed through the mill sluices into the Receiving Basin. By this process, power was generated.

A cross-section of the Mill Dam is shown in Fig. 3-1. The dam had two stone walls, north and south, resting on timber piles which penetrated into the mud bottom. The stone was brought from Roxbury and Weymouth. Stone ballast was placed behind both walls. The core of the dam was filled with about ten feet of mud. Another five feet of sand was placed on top of the mud fill. The dam was surfaced and used as a road for transportation. Construction materials were hauled by barge and horse cart. The structure was relatively impervious to the flow of water from one side to the other, however, in an axial direction, the dam is probably quite pervious. Later on, the Mill Dam was widened from fifty feet to seventy feet. The new twenty feet was added on the north face of the dam.

By 1835, two railroads had been laid across the flats - the Boston & Worchester Railroad (later the Boston Albany Railroad) and the Boston & Providence Railroad (see Map 3.2). The former railroad ran from Swell's Point (i.e. now near to Kenmore Square) and crossed the Full Basin, to Gravelly Point by a bridge. From Gravelly Point it ran diagonally from west to east across the Receiving Basin, on an embankment pierced by bridges over channels (see Map 3.2), to the shore near Castle Street (i.e. the original shoreline). The Boston &

Providence Line cut across the Receiving Basin from southwest to northeast (see Map 3.2). The railroad was also built on an embankment and included bridges with similar structures as those of the Boston & Worchester Railroad. The railroad embankments were constructed from gravel material probably excavated from one of the hills in Boston peninsula. The gravel was most likely transported by cart which was the common transportation means at that time.

For many years, the sewage from the City of Boston drained into the Full and Receiving Basins before they were filled. This drainage had created a nuisance for the area. Also, after the two railroads were constructed across the Receiving Basin with an intersection at the center of the basin, the flow of water for industrial power purposes was seriously reduced. Later water was shut off from the basins, the flats of the Receiving Basin dried up and clouds of fine dust blew in every direction which caused even more of a nuisance . A sluice-way was built to keep the flats covered with water at all times in order to avoid the blowing of dust.

3.3 Early Filling

One of the earliest landfills in Boston is that of the West Cove which was done in the beginning of the nineteenth century (for details, refer to Chapter 2, Boston Peninsula). Part of the filled land (Charles Street) extended into Back Bay. In 1815, filling of Back Bay started as a dump site for city ashes and other refuses. These materials were carried by carts and unloaded on the site. By this process, a tract of land running along the original shoreline was reclaimed by mid 1830's (area'BB1' in Map 3.3). The dumping started in the areas to the north and south of

Mill Dam near Charles Street. As this filling progressed, the Public Garden was developed. Additional ashes and refuses were deposited following the trend of the original shore in the southerly and then westerly directions. After this strip of land was filled, there was not much work done in Back Bay in the late 1830's and 1840's. Based on a map for the year 1851 prepared by the engineering firm of Fuller and Whitney, only two small areas were reclaimed during that period, marked as 'BB2' in Map 3.3. These areas were probably also filled with ashes and refuses dumped from carts.

3.4 Major Filling

Most of the filling of Back Bay south of Mill Dam was done between 1858 and 1881 which included the area from Arlington Street to Massachusetts Avenue (areas 'BB3','BB4','BB5' in Map 3.3). In the 1850's, the Boston hills (i.e. Trimountain or Beacon Hill) were completely built over and any further excavation from the hills was restricted. A new source was found in Needham. This material mainly consisted of sand and gravel. Ten to twenty feet of this material was placed over the marshy flats. The flats mainly consisted silty soil which was usually organic in nature. Steam shovels in the gravel pits and a railroad were used for excavation and transportation respectively. The shovel dug the material from the pit and loaded it onto railroad cars. The sand and gravel from Needham was then transported to and dumped into the bay. The process is well described in Ballou's Pictorial for 21st May 1859 and is quoted in Whitehill (1968). Part of it is re-quoted in the following:

'The gravel is brought from Needham, near the line of Newton, a quarter of a mile

from the Upper Falls Depot, and nine miles distant from Boston. One hundred and forty-five dirt cars, with eighty men, including engineers, brakemen and all, are employed, night and day in loading and transporting the gravel over the road. The trains consist of thirty-five cars each, and make, in the day time, sixteen trips, and in the night nine or ten, or twenty-five in twenty-four hours. Three trains are continually on the road during the day, and one arrives at the Back Bay every forty-five minutes. The excavators for loading the cars work by steam, and perform the work with rapidity and ease. There are two of them, both of which are propelled by engines of twenty-five horse power. The gearing of the engines is so arranged, however, as to greatly augment their power. When an empty train arrives at the pit, it is divided, and one half is fed by one excavator and the other half by the other. A locomotive is attached to each half, and the cars are drawn past the excavators, to be filled. Two shovels-full fill a car, the operation being very much like that of a dreding machine. As the shovel is elevated from the pit, it is turned towards the car, and when directly over it the bottom is opened, and thus the gravel is deposited. The time occupied in loading an entire train of thirty-five cars is about ten minutes. The excavators do the work of two hundred men. The process of loading the cars, though very simple, is curious and interesting. During the year the contractors have been at work, there have been taken out of the hills of Needham about three hundred thousand yards of gravel. Some of the sand-hills which have been levelled were fifty feet high, and the plain which has been made by the machines in excavating, is about twelve acres in extent. The farm from which the sand and gravel are taken belongs to the Charles River Railraod Company.

When the contractors commenced operations there was a mortgage upon the land. They, the contractors, agreed, on their part, to lift the mortgage, and the Railroad Company agreed without further compensation to give the sand. It is believed that the excavation and filling in are going on at a more rapid rate that has ever been known in the history of any similar contract in the country. The contractors make, in the Back Bay, on an average, about twenty-five hundred cubic yards, or forty-five hundred superficial feet per day. This is equal to nearly two house lots.'

Fig. 3-2 shows the steam shovel loading gravel for the Back Bay. As mentioned in Ballou's Pictorial, the rate of the process was very rapid. The excavation and filling was done twenty-four hours a day. In about twenty-four years, Back Bay was transformed into a solid piece of land. The progress of work can be best understood by reference to a series of maps prepared in the 1880's by the engineering firm of Fuller and Whitney, showing the shoreline of Back Bay at ten-year intervals. These maps are summarized in Map 3.3. Area 'BB3' was filled between 1858 and 1861. The 1861 shoreline of the Receiving Basin was just west of Clarendon Street. Area 'BB4' was filled between 1861 and 1871. Boylston and Newbury Streets and the south side of Commonwealth Avenue were reclaimed to Exeter Street, while the north side of Commonwealth Avenue reached Gloucester Street, and Marlborough and Beacon Streets were reclaimed as far as Hereford Street. By 1881, the entire area of Receiving Basin was filled, although not necessarily built upon. Area 'BB5' was the last piece of land filled in the basin between 1871 and 1881.

Occasionally, rubbish and oyster shells were used as supplement to the Needham sand and gravel. These other two materials are widespread in the of Back Bay area but they are volumetrically minor portions when compared to the sand and gravel.

Concurrent with the filling, a seawall was constructed along the Charles River to create Back Street (see Map 3.3) which parallels Beacon Street on the water side. In Fig. 3-3, a cross-section of the seawall is shown. It is composed of dry-laid granite placed on a timber platform and supported on wood piles. It was ballasted with stone or gravel like the Mill Dam walls. In 1865, the Back Street seawall was extended along the Charles River (see Map 3.3, 'extension of Back Street seawall').

The areas behind the Back Street seawall and its extension (areas 'BB3A','BB4A','BB4B' and 'BB5A' in Map 3.3) were filled with material obtained from the river. The material excavated from the river was mainly silt, and it was loaded onto scows from which the silt was dumped directly into the water for low grades. (Scows are boats with drop bottoms used for dumping filling material.) For high grades, the silt was shovelled from scows and then placed onto the flats. Shovelling was also used for the top layer of fill which was about ten feet. A gravel layer of about three feet was used as surfacing material which was brought in by carts. Area 'BB3A' (see Map 3.3) was filled between 1858 and 1861, areas 'BB4A' and 'BB4B' were filled between 1861 and 1871 whereas area 'BB5A' was filled between 1871 and 1881.

3.5 Storrow Drive and Esplanade along Charles River

The strip of land three to four hundred feet wide, used as Storrow Drive and esplanade, on the Boston side of Charles River was filled during the period 1929 to 1931. It extends from Charles River Dam to Charlesgate West (area'BB6' in Map 3.2). This is the last landfill for Back Bay. Filling material was obtained from the bed of the river by hydraulic dredges and slurry dumping. The land created for the esplanade was loamed, planted with shrubbery and trees.

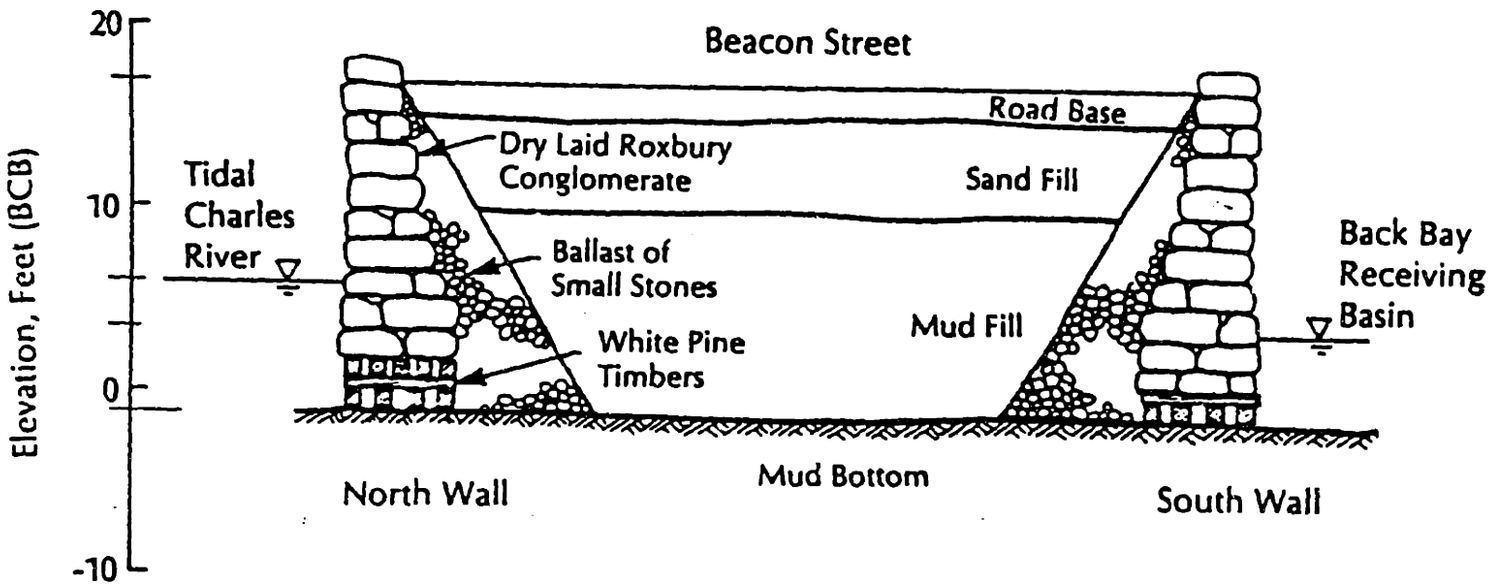

Figure 3-1: Cross-section of the Mill Dam (Aldrich, 1986)

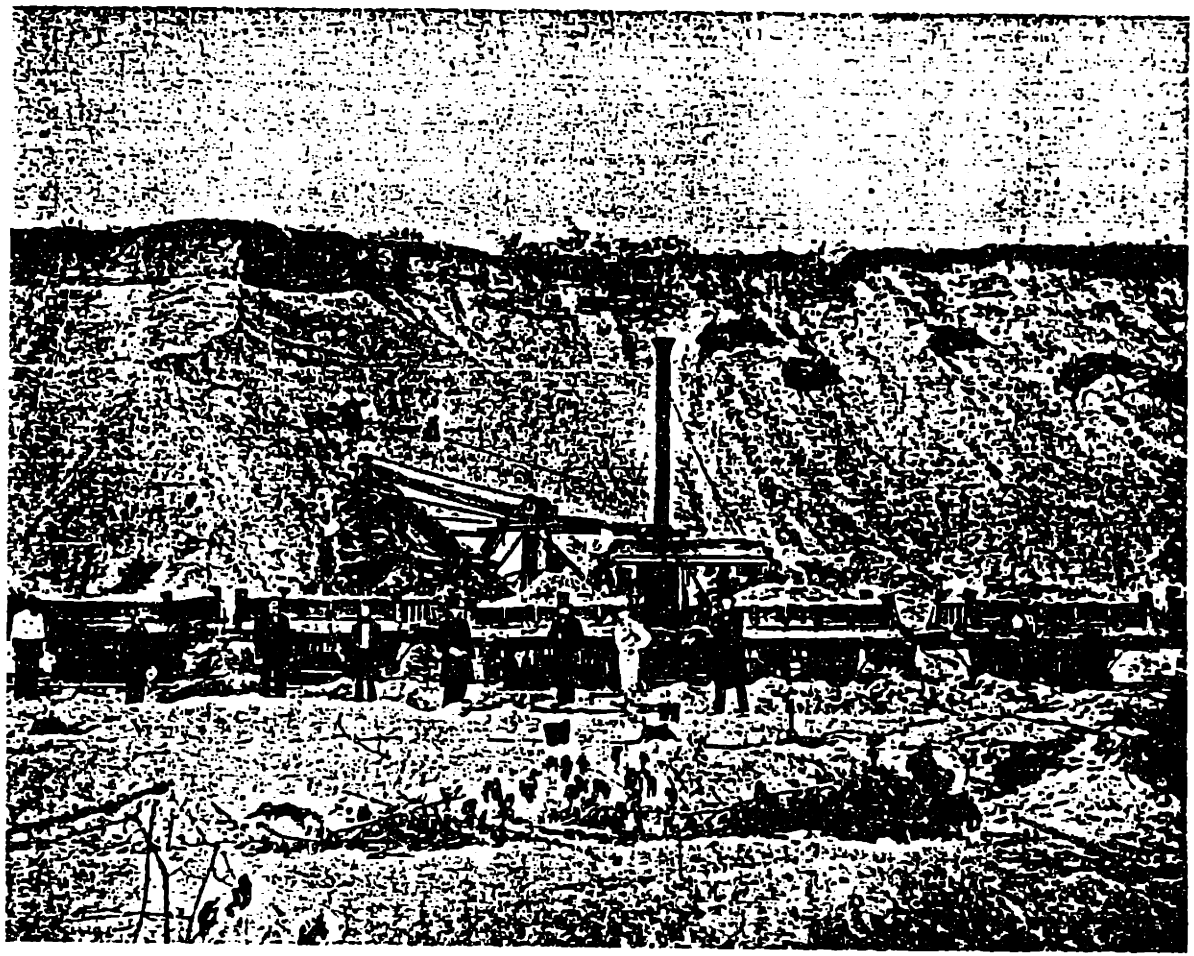

Figure 3-2: Steam Shovel loading gravel for the Back Bay (Whitehill, 1968)

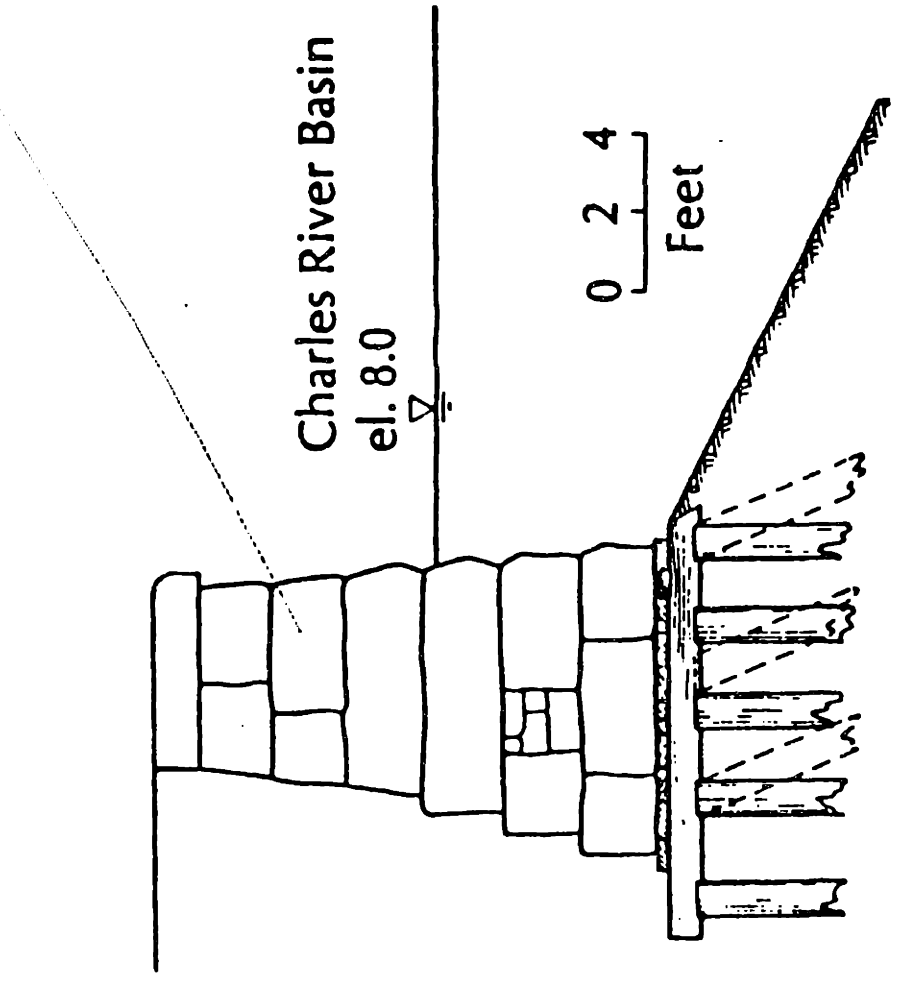

Figure 3-3: Typical Cross-section of the Seawall along Back Street (Aldrich, 1986)

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Chapter 4

Back Bay Fens

4.1 Introduction

This is a piece of land, with a surface area over three hundred acres, to the west of Back Bay. The area originally consisted of marshes with winding rivers - Muddy River, Stony Brook, Great Creek and Longwood Stream (see Map 4.2). Map 4.2 also shows the original shoreline of the area. The area was known as Full Basin after the construction of the Mill Dam and the Cross Dam in 1820's (see Map 4.2). The basin was used for generation of water power. When the Boston and Albany Railroad was built in the 1830's, part of the rail line ran across the Full Basin to Gravelly Point (see Map 4.2). As the greater part of the Receiving Basin (ie now Back Bay) was filled in (see Chapter 3, Back Bay), the Full Basin became useless for power generating purposes. It served as a sedimentation basin for all the sewers of Roxbury plus some of those of Brookline and Brighton, and as the receptacle of any pollution that might be carried in the Muddy River.

Most of the filling of Back Bay Fens was started in the late 1870's as a continuation to the filling of Back Bay and due to the construction of Back Bay Park in the area. It lasted for more than ten years. Gravel delivered by the Boston and Albany Railroad, material dredged from the Charles River and excavation from the river channel in the park were the main sources of filling material.

4.2 Filling Along the Charles River

The region north of Beacon Street and east of Beacon Entrance of the park (area 'F1' in Map 4.3) was filled in 1881 and 1882. A seawall was constructed along the Charles River (seawall 'A' in Map 4.3). The structure of the wall was similar to that of Back Street Seawall in Back Bay. Material, mostly silt, was dredged from the river channel. Two machines were used for dredging, and excavated material was loaded onto scows. Then, the material was dumped from the scows for low grades and shovelled from the scows for high grades on the flats. Filling with excavated material from the river was done to grade ten above mean low water, on top of which was spread a covering of three feet of dry filling, mainly gravel, brought in by carts.

Concurrent with the filling of area 'F1', a region on its west (area 'F2' in Map 4.3) was filled. In 1881, the Boston and Roxbury Mill Corporation was given the permission to extend the seawall along the Back Street (seawall 'B' in Map 4.3) to the west of Beacon Entrance so that the river front of 'F2' was protected. Pile foundations were required and about six hundred wooden piles were driven. They had an average length of twenty-eight feet below mean low water. Gravel was used to pack around the piles so as to displace the mud and to hold the piles firm. At first, gravel was excavated from the river to fill in the flats between the seawall and Beacon Street. After a few months, mud was dredged from the river and used as filling material. In November 1881 (Fuller, 1881), gravel was dredged from the Charles River bed opposite Clarendon Street (marked as 'G' in Map 4.3) and

dumped into the area. The gravel dredged was very interesting because the color and weight varied much, some was coarse and some was very fine even though found at the same place. Scows were used to carry and deposit the excavated material.

In the mid and late 1880's, filling along the Charles River continued. Reclamation of land now reached up to Brookline Street (area 'F3' in Map 4.3). The seawall was extended further along the river (seawall 'C' in Map 4.3). A suction dredge supposed to be used on the Cambridge shore was moved to Boston side for filling the area. (The river bottom in Cambridge was too hard for the equipment so it was used on Boston side which had a softer bottom.) Some of the sewage near the mouth of the Muddy River was pumped and most of the material from the Charles was mud and silt. The filling process was completed in 1889 just as the dredge was destroyed by fire. Bay State Road was thus created running parallel to the Commonwealth Avenue. The work of dredging resulted in the removal of the unsightly flats in front of the seawall which were exposed at low water, and the channel of Charles River was deepened for navigation.

In 1929 to 1931, Storrow Drive was constructed along Charles River and part of it (area 'F9' in Map 4.3) was situated north of seawalls 'A','B' and 'C'. The area was filled with silty material dredged hydraulically from the river.

4.3 Filling South of Beacon Street

An area bounded by Beacon Street to the north, West Chester Park (ie now Massachusetts Avenue) on the east, the Boston and Albany Railroad on the south and Brookline Avenue on the west was filled in the early 1880's. This area was divided into two portions, east (area 'F4' in Map 4.3) and west (area 'F5' in Map 4.3) which were filled with different materials. Filling of area 'F4' began in 1880 with gravel from Riverside brought by cars of the Boston and Albany Railroad. Small amounts of ashes were dumped into this area as a supplement to the gravel. The work had diverted the water flow from Muddy River and Stony Brook. Area 'F4' was completely filled in 1882 by the railroad company.

Area 'F5' was filled by means of a new device called 'steam scoop' started being used in 1881. The machine was designed for excavation below water level and it was very useful in dredging the channel for the new waterway of Muddy River. The operation was done by dragging a scoop across the water and the material dredged was lifted to the shore. The bottom of the waterway was mostly mud which was too soft for men to work on it. The soft excavated mud was dumped into area 'F5' and was then covered with gravel carried in by railroad. The filling process for this region was completed in 1883.

4.4 Filling South of the Boston and Albany Railroad

In 1881, a steam-dredge and several scows were being built for later use in the park work. In the following year, the steam-dredge was launched and four scows were involved in the work. The dredge excavated the channel and the scows dumped material which formed shores of the channel and filled areas behind the shore. Area 'F6' shown in Map 4.3 was the land filled at this stage with material excavated from the channel running through area 'F6'. Material was excavated by the dredge then loaded onto the scows from which it was dumped into appropiate places. Fig. 4-1 shows the work of the steam-dredge and scows in the park. When the material excavated was gravel, it was used for building an embankment (embankment 'A' in Map 4.3) on the shoreline of the channel. If mud was excavated, it was deposited in the rear of the embankment. The gravel embankment was constructed for retaining the mud dumped from scows. During the first year, about four thousand linear feet of shoreline was formed, and the channel between the banks was excavated to mean low water. This initial work started in the northern portion of the park (i.e. near the Boston and Albany Railroad) and it was continued southward.

In 1883, all of the available gravel from the water was dredged, and the Boston and Albany Railroad Company would have to be depended upon for the additional material needed to complete the shorelines of the channel. Gravel transported by railroad was dumped south of the rail line and was then carried (no detailed information is available on how this was done) to the park for construction

of embankment. In that year, about three thousand two hundred feet of shoreline was constructed and the amount excavated by the steam-dredge was over sixty-one thousand cubic yard. The process continued in the same manner for another two years. By the end of 1885, the excavated area of channel was over 1 million square feet or eighty-two percent of the whole. The lenght of shoreline completed was eighteen thousand linear feet or sixty-eight percent of the whole. Afterwards, excavation slowed down because most of the places where material could be dumped directly from scows had already been filled. Instead, material was moved into place by wheelbarrows after unloading from scows. Usually, the wheelbarrows required to travel a long distance over soft ground which resulted in a slow and expensive process. In 1891, the last part of excavation near Longwood Entrance was finished. After completion of this work, the dredging plant was sold to the Water Department. The total area dredged during the ten years was over 1.2 million square feet and the total length of embankment completed was about twenty-seven thousand feet.

Surrounding the Back Bay Park, there were roadways and entrances - Beacon, Boylston, Westland, Huntington,Tremont and Longwood (see Map 4.3). Most of the land for these roadways and entrances as well as adjacent land (area 'F7' in Map 4.3) was filled beginning in 1879. The work lasted for over ten years and was finished in the early 1890's. Gravel transported by rail represented the major portion of filling material. In several areas, some other materials were used (refer to Map 4.3 for these regions):

(a) Roadway west of park - ashes carried by carts in 1879

(b) Roadway east of park - ashes carried by carts in 1879

(c) Longwood Entrance - dirt from Parker Hill in 1879

(d) Huntington Entrance - earth transported by carts in 1880

In 1887, a stone-crushing plant was purchased for crushing all the stone used for surfacing roads and walks surrounding and within the park.

Together with park construction in 1880's, covered channels for Stony Brook and Muddy River were built for water flowage. These channels were mainly built of wood. The original rivers (area 'F8' in Map 4.3) were filled with gravel brought in by the Boston and Albany Railroad.

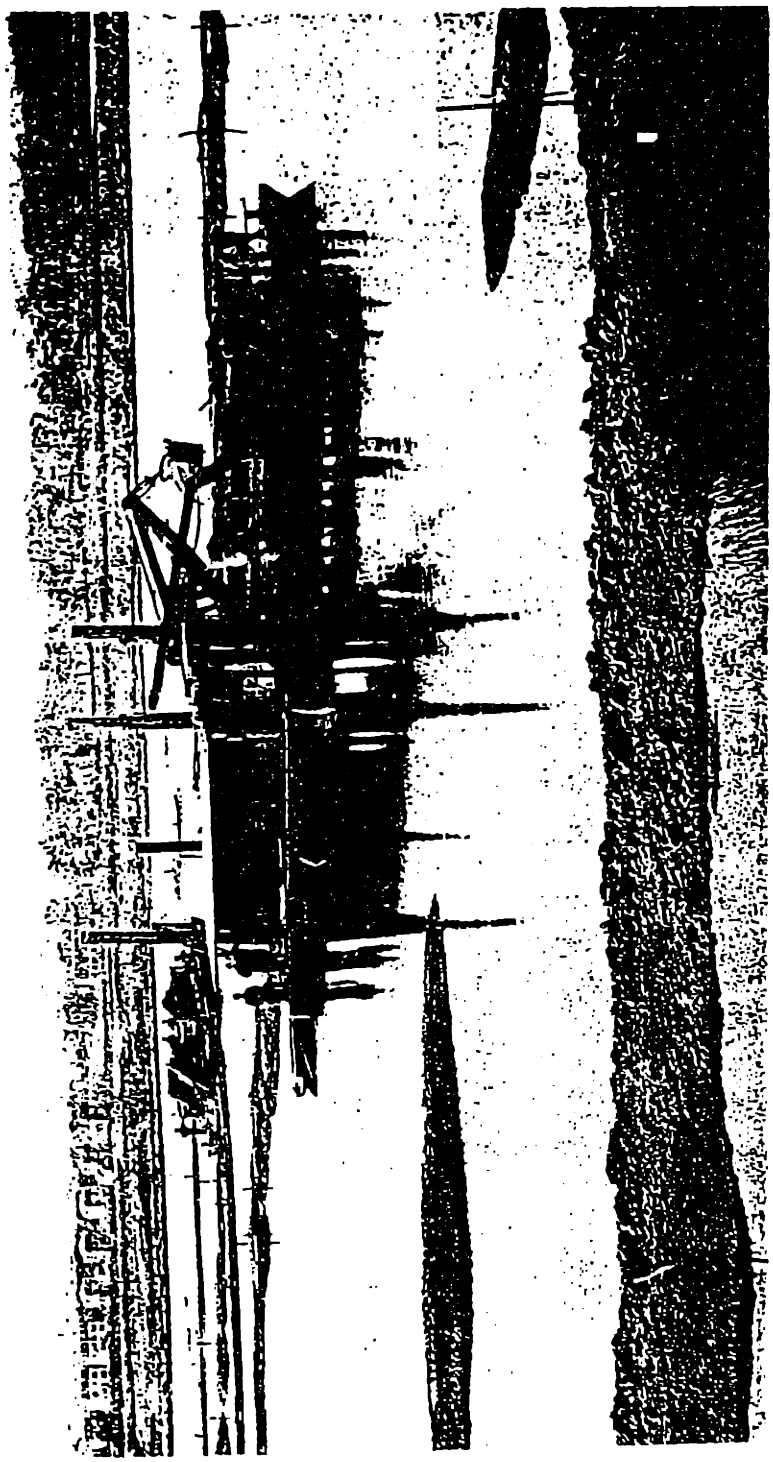

Figure 4-1: Dredging Back Bay Park (Department of Parks, 1882)

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Chapter 5

Cambridge and Allston

5.1 Introduction

Cambridge is bounded by the Charles River on its southern limit. Within the broad floodplain of the river were extensive salt marshes bordering the meandering main channel. Springs, ponds and quiet streams- typical of post-glacial New England- were interspersed among low hills. Beyond the first range of hills lay a pond, Fresh Pond, and many acres of shrub and tree swamp draining into a smaller river, the Menotomy or Alewife Brook.

The underlying bedrock in and around Cambridge is chiefly argillite, a slate-like rock, lying from fifteen to two hundred feet below the surface with almost no outcropping. Cambridge is inside the area of Boston Basin with sand plains and clay beds over the argillite which also extends under parts of Boston. Several of the hills in Cambridge are morainal features or drumlins deposited, probably, by the late Wisconsin glaciation. Re-advance of the ice is thought to have formed the Fresh Pond moraine. This ridge (see Fig. 5-1), the highest in the city, is composed of sand, gravel and clay.

Most of the fill sites studied in Cambridge are along the Charles River. Much of the area was marshy and part of it belonged to the river basin. Topographic changes occurred as early as in the eighteenth century, through construction of

bridges and connecting roads, and continued to this century when the parkway along the Charles River and the river dam were built. The original three islands: Lechmere's Point, Pelham's Island and Captain's Island (see Map 5.2) disappeared when adjacent marshy flats were filled in. Pelham's Island was the earliest to be connected to the mainland at the beginning of development in Cambridgeport. Lechmere's Point, the biggest of the three, was actually a small hill/drumlin of about forty to fifty feet height and covered a significant portion of the East Cambridge. Map 5.1 is a base map for most of the area of Cambridge and Map 5.4 is a base map for Allston and the rest of Cambridge.

In the early stage, filling materials were obtained from the leveling of hills, which can be easily shown by comparing the original surface elevation with that of a present map. Ashes and refuses were dumped into the marshy land by the city. Railroads carried gravel from pits. After the invention of the hydraulic dredging machine, a very large amount of material was dredged from the river.

5.2 Bridges and Embankment Roads

Pelham's Island and Lechmere's Point were connected to the old city of Cambridge and to Boston by embankment roads and bridges. Bridges were built over the Charles River linking the city with Boston. Development of Cambridge started with the building of West Boston Bridge (see Map 5.2), which is at the site of today's Longfellow Bridge, in 1793. Another bridge in East Cambridge, the Canal/Craigie's Bridge (see Map 5.2), was constructed in 1807 where the Charles River Dam now stands. Both structures were supported on wooden piles. Roads

were laid out with embankment portions built over tidal areas; specifically, these were Main Street which led to the West Boston Bridge, as well as Broadway, Beacon Street, Cambridge Street, Portland Street and Somerville Avenue (see Map 5.2). These embankment roads protected the surrounding marshes from the tidal flow and made it possible to fill these marshy areas later on.

In the 1850's, the Grand Junction Railroad Embankment (see Map 5.3) was constructed across the river marshes of Cambridge, it formed a dike which kept tidal water from the low-lying area on its inland side, thus creating additional land available for filling.

5.3 Early Filling

During the first half of eighteenth century, most of the filling work was done in the marsh between Lechmere's Point, Pelham's Island and the mainland (areas 'C1' and 'C2' in Map 5.3). Around 1810, four canals were constructed: North, South, Cross and Broad, all interconnected (see Map 5.3). Because of the marshy terrain, the canal walls were lined with stones. At almost the same period, a piece of land which connected Pelham's Island with the mainland (area 'C1' in Map 5.3) was filled in. It seems reasonable to assume that this area was filled with materials dredged from the four canals when they were excavated. Another possible source of fill are ashes and refuse dumped by the city.

In the 1850's, area 'C2' was filled connecting to 'C1'. Streets were laid out on and around Lechmere's Point. Filling materials were mainly ashes and refuses plus

some cut from the drumlin on Lechmere's Point. After filling in 'C1' and 'C2', most of the embankment roads had solid landfill on both of their sides.

Based on the Journal of the Boston Society of Civil Engineers (Sept., 1931), there was a dam called 'Great Dam' (see Map 5.2) located parallel to Broad Canal. Information on the structure of the dam has not been found.

5.4 Filling of Miller's River and Canals

Miller's River (see Map 5.2) along the north side of East Cambridge was divided into two portions by the Boston and Lowell Railroad. In the 1870's, the upper portion with the boundary a little below the railroad (area 'C3' in Map 5.3) was filled with material dredged from the lower basin. A drain was constructed through the basin discharging below the lowest point of filling. It is unfortunate that the location of the drain cannot be determined because no information about this could be found. Excavation in the lower basin was done to at least one foot below mean low water. During this decade, the North, South and Cross Canals built in the 1810's were all filled while the Broad Canal still remained in use. The source of material for filling in the three canals is unclear but it seems possible that they were filled with the same material used in upper Miller's River, namely material obtained from the Miller's lower basin.

NOTE: The two areas marked 'A' and 'B' in Map 5.3 were filled during the period 1870-1890. The source of filling material is again uncertain. Since area 'A' is close to area 'C3', upper portion of Miller's River, and the three canals which were filled in the 1870's, it is possible that 'A' was filled with the same material, specifically

material from the lower basin of Miller's River. The other possibility is that the Charles River Embankment Company obtained filling material from its flats (i.e. area 'C6') or from the river in front of area 'C6' and deposited it in the 'A' area. The other piece of land , 'B', has the Grand Junction Railroad embankment on its southern boundary but would have been below the water without filling. It seems very likely that the land was filled with materials obtained from the flats lying south of the railroad.

5.5 Seawall, Bulkhead and Adjacent Flats

5.5.1 Craigie's Bridge to West Boston Bridge

In 1892, about six hundred and forty feet of seawall was built. It extended from Broad Canal easterly to Binney Street (seawall 'A' in Map 5.3). The flats behind it were then filled. First Street to the west of seawall 'A' (see Map 5.3) was laid from its terminus at Binney Street to the Broad Canal, where a bridge was built, connecting this region with the junction of the West Boston Bridge and Main Street. A large amount of filling was also done on both sides of First Street between Broad Canal and Binney Street (area 'C4' in Map 5.3). Filling material used was mostly ashes and refuse brought in carts from Boston and Cambridge plus some material taken from the river.

In 1895, another seawall (seawall 'B' in Map 5.3) was under construction in continuation to and of similar structure and dimension as seawall 'A'. Because of unfavorable soil conditions, pile foundations had to be used. The surface of the flats on which this wall was located varied from an elevation at about mean low water to

a level of about eight feet below mean low water. Below the surface was a sheet of mud about six feet thick. The material below the mud was fine, compact sand which was suitable for foundation of the wall but it was about fourteen feet below mean low water at some locations. The wall did not directly rest on the sand instead wooden piles were used as foundation and no excavation of the mud was required. A section of seawall 'B' is shown in Fig. 5-2. A continuous line of hard pine timber six inches in diameter was driven near the front of the wall and was reinforced by a row of large inclined spur piles. The rest of the wall was carried on three lines of piles spaced two feet six inches apart. All the piles were driven to a firm and solid bearing. The spaces between and around these piles were filled with clean, coarse gravel. The piles were cut off at mean low water and covered with a heavy timber platform on which the wall itself rested. The wall consists of a high grade granite masonry, surmounted by a heavy granite cap. Ballast was placed in front of the foundation at deeper portions in order to increase stability. Behind the wall, stone ballast was placed to prevent washing of the filling material through the wall. Filling material was obtained from the river basin adjacent to the wall and the material was dredged and dumped by the suction type method onto the land side of the wall (area 'C5' in Map 5.3). The material pumped from the river was mainly mud and silt. After the area was completely filled, a strip of land along the wall was used as parkway named 'The Front'. As landfilling progressed, Lechmere Canal was constructed in a 'L' shape running across part of 'C5'.

5.5.2 West Boston Bridge to Brookline Street

The triangular piece of flats between the Grand Junction Railroad to the northwest, Main Street on the northeast, and the Charles River to the south (areas 'C6', 'C6A' and 'C7' in Map 5.3) can be considered to be the major landfilled area in Cambridge. Its total surface area is about two hundred and fifteen acres and it consisted of submerged mud flats except for a tongue of marsh with a gravel beach knomn as 'Whittermore's Point' (see Map 5.2) near the present Massachusetts Avenue. At the western end of the trianguiar flats, was an area called 'Oyster Banks'(see Map 5.2), where shells can probably be found underneath the present ground near surface.

In general the soil profile of the area before filling consisted of a layer of mud and organic silt near the surface with significant variations in thickness; also sometimes sand, peat and shells were contained in it. Underneath, there was sand-gravel with the relative proportions of sand and gravel varying widely but containing very little silt. Below this was a thick layer of 'Boston Blue Clay'. Glacial till was found on top of bedrock which occurred at a depth of over one hundred feet below the mud flat surface. The present soil profile is not much different except for the fill that has been added on top of the mud flats.

In 1881, the Charles River Embankment Company was formed which controlled a large portion of the two hundred fifteen acres of flats (area 'C6' in Map 5.3). The first step in developing this land was the construction of a granite seawall on the southern boundary (seawall 'C' in Map 5.3). In 1883, the first one thousand

feet of seawall was built and tons of river silt was pumped and deposited on the flats behind it. With the construction proceeding slowly, two thousand feet of wall (seawall 'C' west of Harvard Bridge in Map 5.3) was completed by the year of 1890. In the same year, Harvard Bridge (see Map 5.3) was completed, and would be ready for use as soon as Front Street (ie. today's Massachusetts Avenue), with which it connected on the Cambridge side, was finished. Since the filling of Front Street could not be completed during summer by hydraulic dredging alone, sixty-five thousand cubic yard of gravel was brought in by railroad cars. During the year 1891, about one hundred sixty-six thousand cubic yard of silty and muddy material was dredged hydraulically from the river and dumped upon the flats west of the Harvard Bridge. The filled area advanced to a line about one thousand five hundred feet west of and parallel to Front Street in the next year. From 1893 to 1896, the work on the property of the Charles River Embankment Company was principally done east of Harvard Bridge. About one thousand five hundred feet of seawall was built along the river (seawall 'C' east of Harvard Bridge in Map 5.3) and about two thousand feet of bulkhead (bulkhead 'A' in Map 5.3) was constructed on its eastern boundary. Filling material was dredged hydraulically from the flats in front of the land between the seawall and the channel of the river. The fill material was surfaced with three feet of gravel which was also obtained from the river. By 1899, there was approximately four thousand feet of seawall and the reclaimed land behind it.

The region bounded by Main Street, the property line of the Charles River Embankment Company and the Charles River (area 'C7' in Map 5.3) with a surface

area of over thirty acres was filled during the late 1890's. A wooden bulkhead (bulkhead 'C' in Map 5.3) formed its northern boundary while the previously constructed bulkhead 'A' formed the western boundary. The region was enclosed by seawall 'D' of two thousand five hundred feet, built in 1898, to the south. The thickness of the mud along the line of the wall varied greatly; in some places little or no mud was found, while in one place hard bottom was about twenty-six feet below low water level. A typical section of the seawall is shown in Fig. 5-3. In preparing the foundation, a trench in the mud was first excavated until hard material was reached; this trench varied in width with the depth excavated. For a part of the distance just enough material was taken out to allow the wall to rest on the natural bed of gravel. The deeper parts of the trench were filled with good gravel obtained from a nearby bank in the bed of the river. In the deepest part of the trench, large quantities of stone obtained from an old wall further up the river mixed with the gravel was used. The wall itself was built with granite masonry placed on the gravel filling with heavy stone ballast placed behind it.

The New England Dredging Company was awarded the contract for filling the area behind the wall. Filling material was taken from the flats lying between the seawall and the channel of the river. Material excavated from the trench when building the foundation of the seawall was also used as fill. A hydraulic dredge was used to excavate and pump the soil, mainly composed of mud and silt with some sand and oyster shells, and to deposit it in the area to be filled. Good clean gravel with a depth of at least one foot was placed on top of the fill.

With the top mud and silt layer removed, there was a large bed of marketable gravel, having an area of about one million square feet contiguous to the seawall 'D' (area 'G' in Map 5.3). Removing this material was delayed because it was too expensive to use the gravel as the major filling material. Eventually, part of it was used for surfacing streets. The rest of the gravel was suggested to be used for grading and gravelling the river banks in accordance with the requirements of the park system (Harbor and Land Commissioners, 1897). But no further information on the usage of the gravel was found.

The filling operation for area 'C7' was completed in 1899 and the flats facing this area on the river side were excavated to a depth of between five and twenty feet. There remained a large bank of gravel (area 'G' in Map 5.3) which was covered by a thin layer of soft material in some places.

Starting in 1901, the fill operation began in the area between the end of the Charles River Embankment Company's seawall on the east and the Grand Junction Railroad bridge on the northwest (area 'C6A' in Map 5.3). The filling process took about three years before completion. A pile and timber bulkhead (bulkhead 'B' in Map 5.3) of about two thousand three hundred feet was constructed along the river side of this area. Materials were pumped by a hydraulic dredging machine from a large area of flats in front of the bulkhead which mainly consisted of mud and silt. By excavating from the river, the surface elevation of the area in front of the bulkhead was lowered to a minimum of eight feet below mean low water.

When filling had progressed to a considerable extent, the timber bulkhead

moved out of line and grade in numerous places because of the depth and instability of mud lying underneath. It was reinforced by driving extra piles along the outer face of the bulkhead and by placing heavy stone and ballast on the outside foot of the bulkhead. Some ashes and dirt were brought in as filling material and placed upon the pumped material. Sandy gravel excavated from the river was used as surfacing material. Also, in 1903, very good quality gravel was taken from a channel dug in connection with the construction of Longfellow Bridge, a new bridge constructed at the same location of and replacing the West Boston Bridge. The gravel from the Longfellow Bridge channel was lying under a layer of mud, and during excavation the mud was first removed and part of the mud was dumped outside bulkhead 'B'.

In 1904, the filling of area 'C6A' was finished. The whole triangular area of flats had become solid land.

5.5.3 Brookline Street to River Street

For the area between Brookline Street and Captain's Island (area 'C8' in Map 5.3), a dyke was constructed on the river bank. This was a mud and turf dyke (dyke 'A' in Map 5.3) about one thousand three hundred fifty feet long which was finished in 1899. The land behind it was mainly filled with gravel. Both the dyke and filling materials were obtained from the river. There was great difficulty in keeping the surfaces to grade because of continuing settlements. In some locations, settlements were over three feet when loaded with about ten feet of fill. When completely filled, the area was used as a playground and a bathing beach, another part of it was

opened as roadway.

A small piece of land between the Grand Junction Railroad and Brookline Street (area 'C8A' in Map 5.3) was filled with mud obtained from the channel dug in connection with the Longfellow Bridge. The water front of this piece of land was lined by an extension of the mud dyke 'A'.

In 1901, filling of the flats to the north of Captain's Island and south of River Street (area 'C9' in Map 5.3) had begun. Filling was slow and lasted for over ten years. A large portion of filling material was ashes dumped by the Street Department of Cambridge. In addition, in 1903, a considerable amount of mud was obtained from the river channel adjacent to the Longfellow Bridge and dumped into the area near River Street (area 'C9A' in Map 5.3). In the same year, when area 'C6A' was being filled, a surplus amount of silt dredged in front of area 'C6A' was deposited in area 'C9A'. In 1911, filling material was recieved from the Cambridge Red Line subway construction. The material was mainly placed on the track of marsh land along the river between Captain's Island and River Street (area'C9B' in Map 5.3). Filling the whole area of 'C9', 'C9A' and 'C9B' was completed in about mid 1910's.

5.5.4 Above River Street/Allston

During 1898 to 1902, the Metropolitan Park Commission was progressing with the work on the south side of Charles River between Boylston street and the Arsenal Street bridge (area'C10' in Map 5.5). Material was excavated from the river basin. Most of the material excavated was gravel but other materials such as mud

and silt were also dredged. All these materials were obtained along the river adjacent to the site and long sections were excavated to depths ranging from ten to twenty feet below mean low water.

5.6 City Dump Site

The site of the former Cambridge City Dump (area 'C11' in Map 5.5), located in North Cambridge, consisted of fifty-two acres of land near Fresh Pond. The site was a clay pit, with excavations forty to fifty feet below the surrounding surface. The City of Cambridge bought the site in 1946 and began refuse dumping operations. Clay excavation also continued on part of the site until 1951. The landfill capacity of the site was exceeded and was closed to the public in 1971, although the city continued to dispose leaves, trees, excavation materials and building rubble until 1979. The thickness of the refuse fill ranged from fifty to seventy feet. The perimeter of the entire site is lined with a stone filled vent trench to prevent lateral migration of methane gas off the site. Later on, additional fill was deposited by the MBTA from the Redline Extension Northwest which consisted of materials varying from blasted rock to silty clay and included construction rubble. The site has now been developed into an athletic complex. Fill materials for the complex can be summarized as follows:

(a) Football/track field - silty sand and gravel over blasted rock fill.

(b) Baseball/soccer field - significant amounts of clay of varying properties.

(c) Football practice field - thin sandy layer over predominantly clay material.

(d) Perimeter slopes and stadium slopes - coarse-grained filling material.

Figure 5-1: Original Topography in Cambridge (Emmet, 1978)

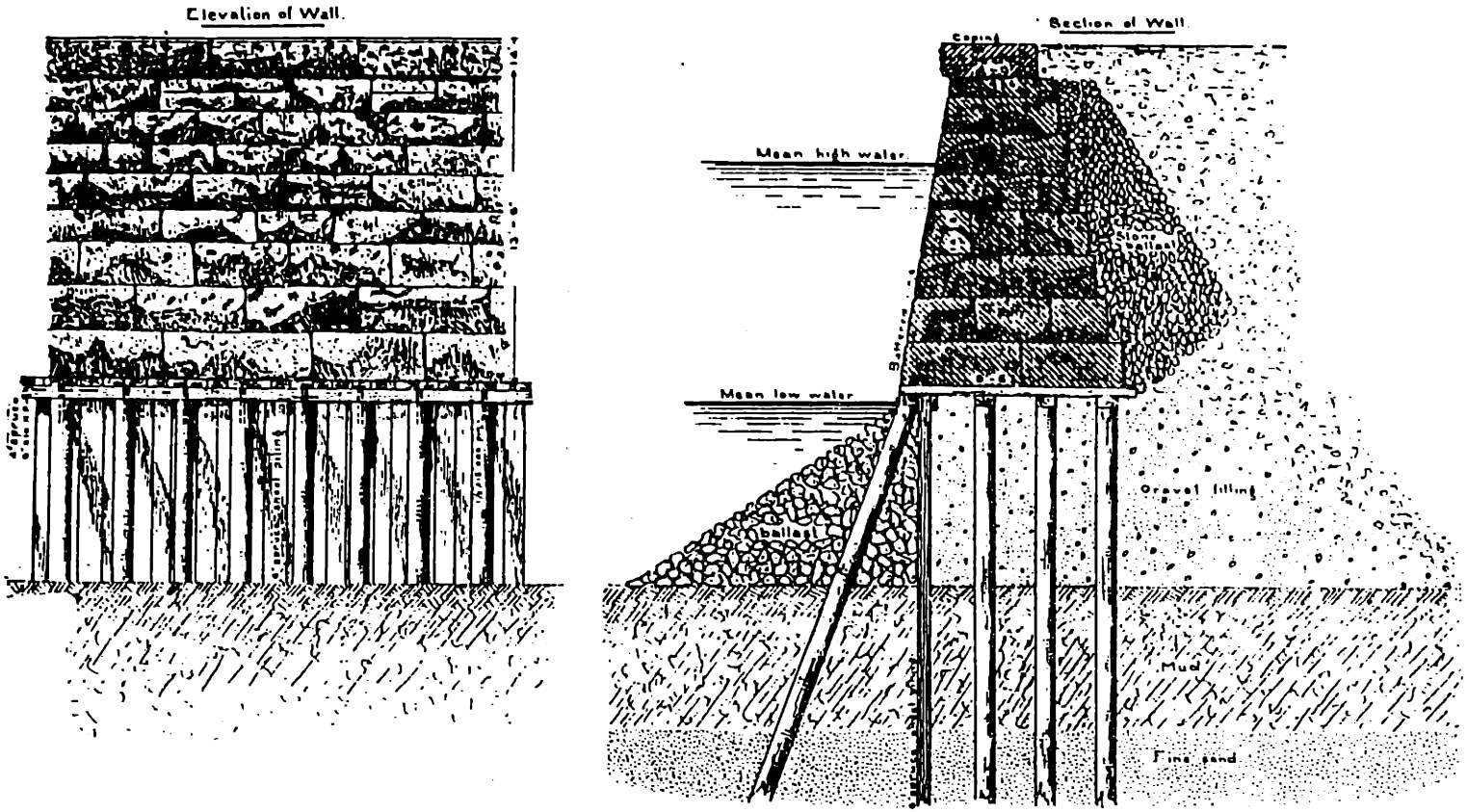

Figure 5-2: Typical Cross-section of Seawall 'B' (City of Cambridge Park Department, 1895)

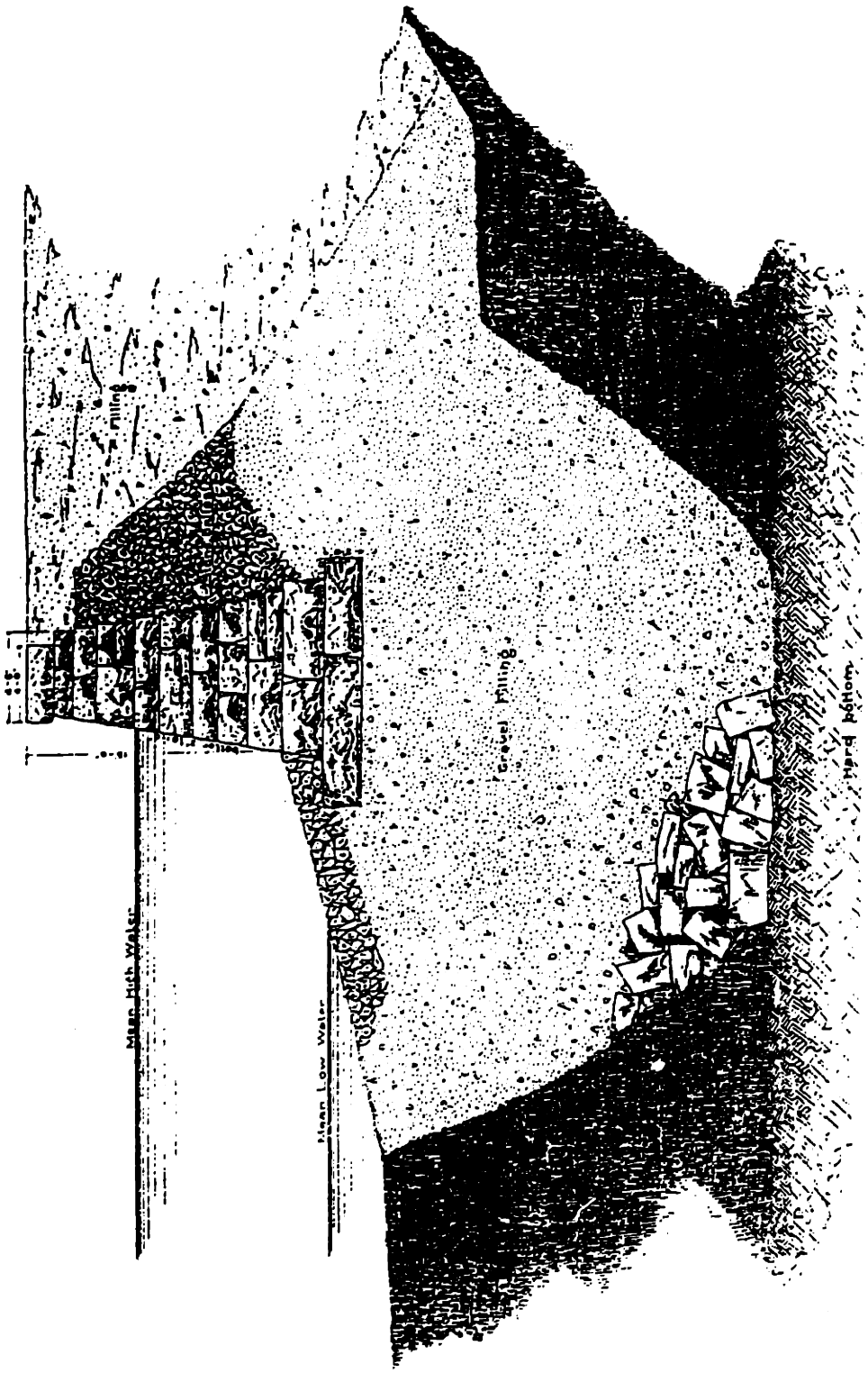

Figure 5-3: Typical Cross-section of Seawall 'D' (City of Cambridge Park Department, 1897)

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Chapter 6

Charlestown

6.1 Introduction

Charlestown was originally a triangular peninsula. It was connected to the mainland through a neck at the northwestern part of the town. The original shoreline is shown in Map 6.2. Charlestown is located to the northeast of East Cambridge/Lechmere's Point. It was once the site of the junction of the Charles, Miller's and Mystic Rivers. The peninsula is characterized by two drumlins known as Bunker and Breed's Hills (see Map 6.2).

All the areas surrounding the original peninsula were filled. A lot of the filling was related to railroad construction. The Charlestown Navy Yard involved filling of an area southeast of the peninsula. Mystic Wharf construction contributed quite a large portion of filled land. Different filling materials were used. Bunker Hill was cut more than once, material dredged from the Mystic River, and some city ashes and refuse were also used as filling material.

6.2 Charlestown Navy Yard

Charlestown Navy Yard was founded in 1840 when it had only twenty-three acres of land along the waterfront. By the time of its closure in 1974, the yard comprised over one hundred acres. Facilities expanded from sawpit, timber shed, cobb wharf, blacksmith and carpenter shops, and guard barracks of the early days

to the densely built industrial complex of piers, dry docks, forges, shops, cranes, and laboratories that existed a few years ago. Most of the land was filled in the first forty years and thus this study concentrates on the early period of the navy yard. The navy yard's filled land is shown as area 'CT1' in Map 6.4 and more detailed maps showing how the filling progressed are given in Fig. 6-1 to Fig. 6-4.

A site plan of the navy yard in 1800 is shown in Fig. 6.1. There was a five acre marsh at the centre of the site. A dam named 'Ebenezer Breed's Dam' was located along the northern side of the marsh. The eastern portion of the site was marked as elevated ground which was actually a small hill.

In 1802, a cobb wharf was completed and its location is shown in Fig. 6.2. The wharf was made of stones and brick. The basin behind the wharf was used for keeping masts, yards, timbers, etc., preserved under water. The depth of water in the enclosed dock varied from three to nine feet. A canal was excavated connecting the dock to the Charles River. Excavated material was placed in vicinity of the canal and thus a bank of sand and clay was created (see Fig. 6.2).

In 1821, New Road was laid running across the yard (see Fig.6.3). The small hill at the eastern portion of the yard was cut and the material obtained was used to build the road. Most of the material was gravel. The area to the north of the road was also filled with this gravel material. Also, a trench was cut south of the road and material from the trench was used to fill the road.

In the 1830's, a quay wall was built forming the boundary of the whole navy

yard (see Fig. 6.4). The wall was made of granite stone and it had a height of fourteen feet. The most economical procedure was used for the construction. Stone was carried by vessel from the quarry and then placed directly at the location of the wall. The area behind the quay wall was filled except for three timber docks (see Fig. 6.4). Filling Material was again obtained from the small hill.

6.3 Around City Square

City Square located at the southern tip of Charlestown (see Map 6.2). Development of the town began in this area. In 1786, the first bridge, Charles River Bridge (see Map 6.3), was built across Charles River connecting Charlestown to Boston. Another bridge named Warren Bridge (see Map 6.3) was built in 1828. Later, Prison Point Bridge (see Map 6.3) was built but the year of construction is not found.

To the east of City Square, there was a protected deepwater cove known as the Town Dock (see Map 6.2). The dock played an important role in trade and shipping for many years. By the mid eighteenth century, the dock consisted of three fingers (see Map 6.3). A dry dock formed the centre finger, while the eastern and western fingers were surrounded by privately-held lands developed into wharves. Two types of wharves were built. The eastern wharf was of timber construction consisting of horizontal wood planks supported by horizontal retaining timber which in turn was supported by pilings. The western wharf was of masonry construction. A seawall (seawall 'C' in Map 6.3) consisting of cut granite blocks nearly one foot width was built and retained filling material behind it. In the early

nineteenth century, the dock became less important because its dockage was not big enough. A bridge along Water Street was built which obstructed the entrance to the dock. Thus, the dock was becoming a nuisance. In the 1830's, some suggestions came up with filling the dock. In 1835, a fire swept across the area surrounding Town Dock. After that, the dock (area 'CT2' in Map 6.4) was filled with rubble from the fire.

In 1836, the Charlestown Wharf Company was established. It purchased all the property along the shore between Prison Point and Warren Bridges. A seawall (seawall 'A' in Map 6.3) was constructed. It was about twenty-six hundred feet in length. The wall was constructed of granite stone but its detailed structure is not known. The area behind the wall (area 'CT3' in Map 6.4) was filled. The filled area was partly used by the Charlestown Branch Railroad (see Map 6.3). It also provided dockside access for loading goods onto ships.

In 1843, the Fitchburg Railroad acquired the wharf company. The Fitchburg continued the process of filling flats and wharfing out between the Prison Point and Warren Bridges (area 'CT4' in Map 6.4). Three years after that, the Fitchburg Railroad (see Map 6.3) was finished. Both 'CT3' and 'CT4' were probably filled with material obtained from Bunker Hill because the hill was cut in the 1830's and 1840's.

In the 1880's, the Boston and Maine Railroad was filling an area east of the Prison Point Bridge for its track (area 'CT5' in Map 6.4). The source of material for this area is not known. This filling separated the channels of the Miller's River and

the Charles River.

6.4 Mill Pond and Adjacent Flats

The original shoreline to the west of the Charlestown peninsula ran approximately along today's Main Street (see map 6.3). There were large flats to the west of the shoreline. In some early maps of the eighteenth century, a mill dam was shown across the flats enclosing a mill pond (see Map 6.3).

In the late 1870's and early 1880's, the flats to the northwest of the Boston and Maine Railroad including the mill pond (area 'CT6' in Map 6.4) were filled. Filling material was obtained from Bunker Hill. An overall surface area of forty-five acres of the hill was excavated (marked as 'E' in Map 6.4). The summit of Bunker Hill was originally ninety-nine feet above mean high water while the grade after cutting was fifty-two feet. The deepest cut was at North Mead Street where fifty-nine feet were excavated. All the excavated material was used to fill the mill pond and the flats south of the mill dam which had a total surface area of about eighty acres. Thirty-five percent of the filling material was dumped into the area of the mill pond while the rest was for the flats. Filling began on the eastern side along Main Street and progressed in a westerly direction. Rutherford Avenue (see Map 6.4) was laid before the whole area was filled.

Filling material from Bunker Hill was transported by cars running on rails supported on a wooden frame along Eden and Auburn Streets (see Map 6.4). The distance from the center of Bunker Hill Street, by direct lines extending through the

streets, to the mill pond and flats was about one thousand three hundred feet; the average distance to carry the earth was about two thousand feet. After being transported on rails, the filling material was dumped directly onto the final site.

6.5 Mystic Wharf

During the years of 1888 to 1892, Mystic Wharf was built. It is located to the north of Charlestown peninsula. The wharf is shown as 'CT7' in Map 6.4. It covers a surface area of about ninety acres. The construction was done by the Boston and Maine Railroad.

A seawall was built at the northern side (seawall 'B' in Map 6.4) and a wooden bulkhead was built at the western side (bulkhead 'A' in Map 6.4) of the area. The seawall is over three thousand feet in length. A trench was dredged at the location of the wall for its foundation. A pile platform was built in front of the seawall. No detailed description or cross-section of the seawall is found. It is suspected that seawall 'B' has similar structure as that of the seawall in South Boston built at about the same time (see Chapter 8, South Boston).

Filling material for 'CT7' was obtained mainly from the Mystic River in front of seawall 'B'. Material dredged from the river was transported by scows and was dumped directly into the area. When the filling material had reached a level such that the scows could no longer enter the area, the material was rehandled by hydraulic dredge. Besides the dredged fill, a considerable amount of ashes and refuse was dumped by carts into the area. Finally, a layer of sand and gravel was placed

on the surface.

NOTE: No information could be obtained on how the area west of 'CT7' (area 'U' in Map 6.4) was filled. It is possible that this area was also filled with material from the Mystic River.

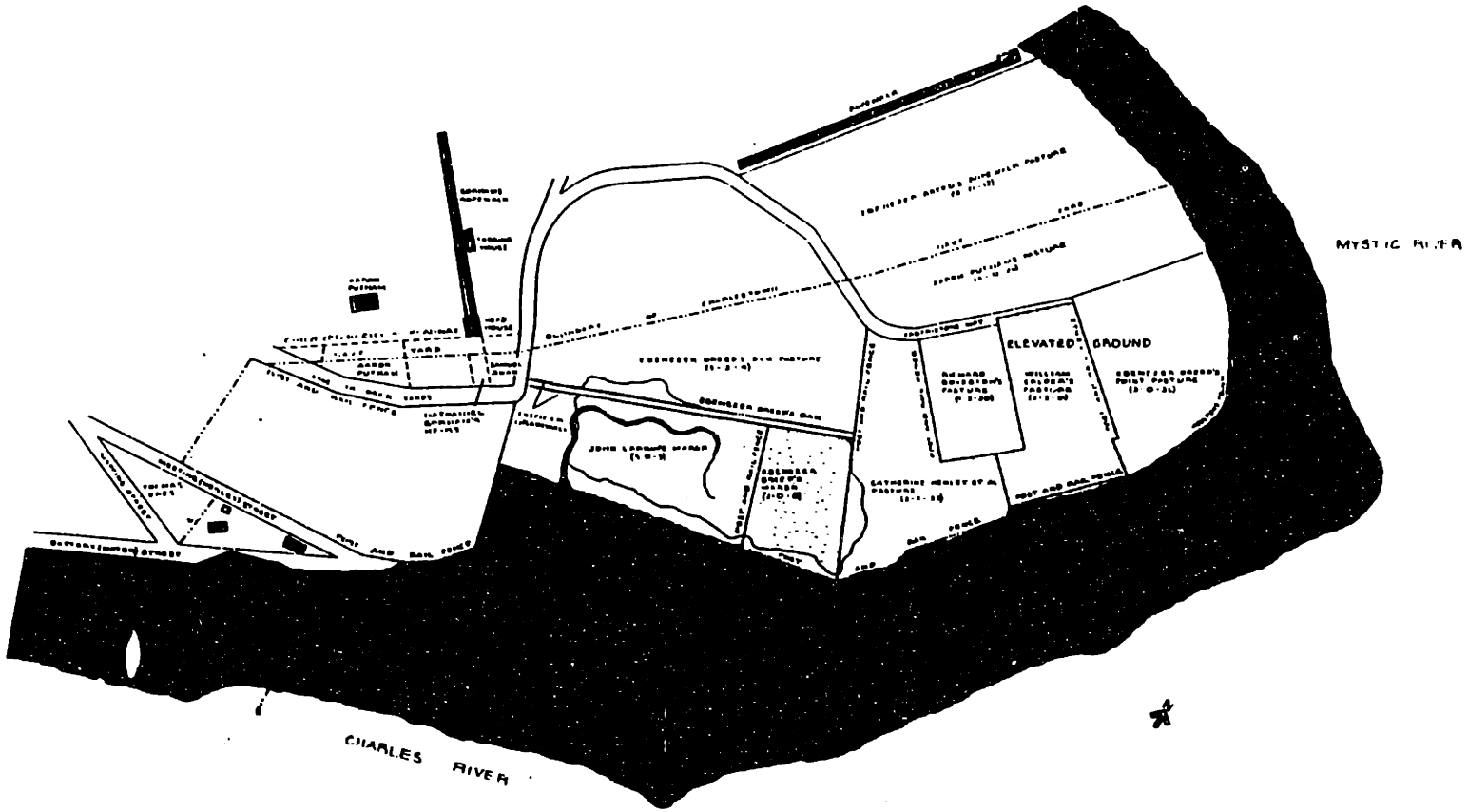

Figure 6-1: Charlestown Navy Yard in 1800 (National Historical Park, 1984)

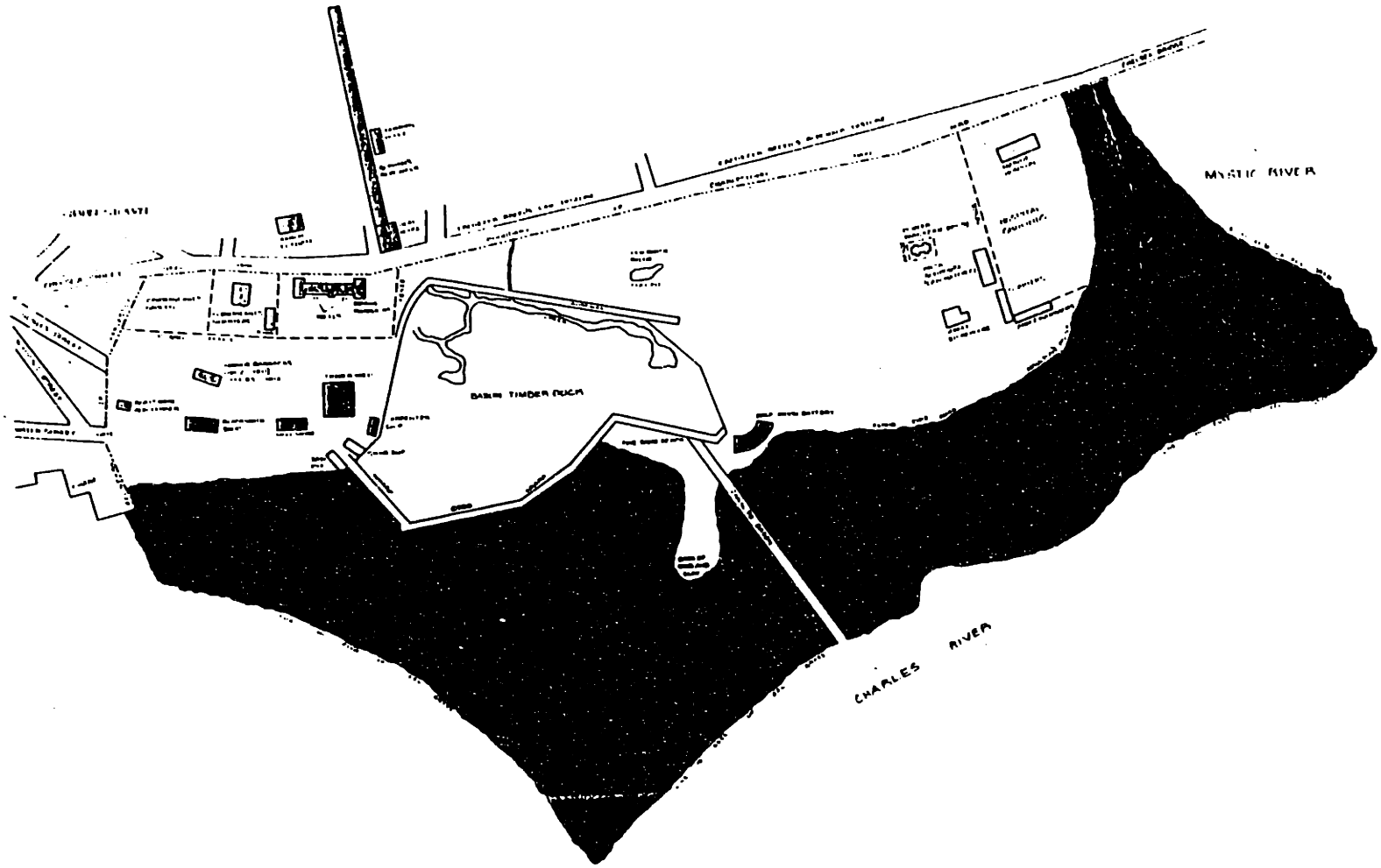

Figure 6-2: Charlestown Navy Yard in 1812 (National Historical Park, 1984)

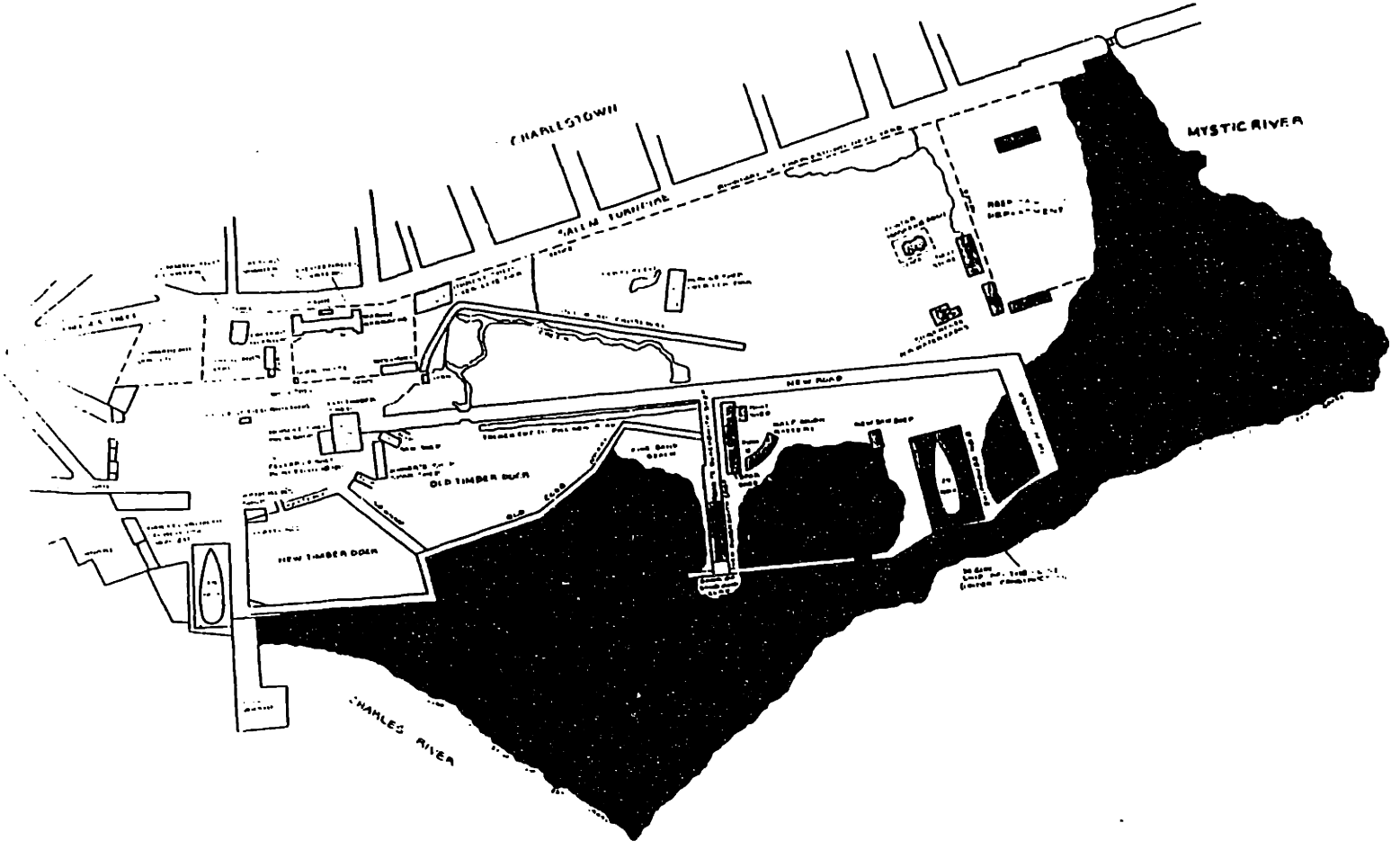

Figure 6-3: Charlestown Navy Yard in 1823 (National Historical Park, 1984)

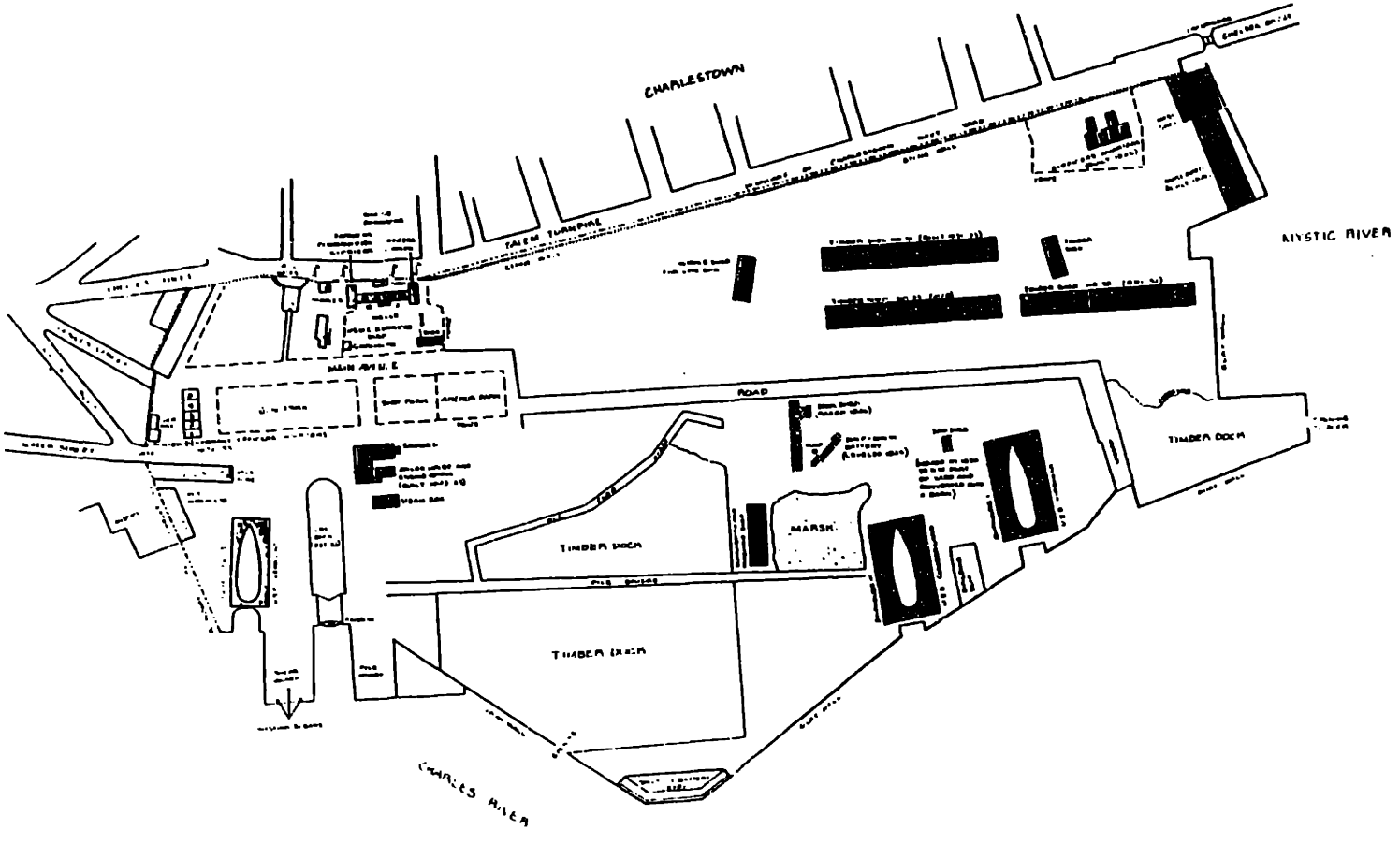

Figure 6-4: Charlestown Navy Yard in 1834 (National Historical Park, 1984)

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Chapter 7

East Boston

7.1 Introduction

East Boston originally consisted of five islands: Noddle's, Breed's, Governor's, Apple and Bird Islands (see Map 7.2). Fill operation started in the 1830's and the lastest was done in the 1960's. Hills were cut to fill the marshes, flats were dredged with hydraulic machinery, and additional material was brought in as the separate land masses of the islands were connected with one another and extended out into Boston Harbor.

7.2 Beginning of Development

Noddle's was the biggest island and its chief feature was a one hundred fifty feet hill - a drumlin (Eagle Hill in Map 7.2). The original shoreline and marsh line of the island are shown in Map 7.2. Development of East Boston began on this island. A survey made in 1801 by William Taylor (Moffet, 1971) shows three pieces of marsh land - Hog Island Marsh on the northeast, Great Marsh occupying a large central area of the island and Camp Hill Marsh located next to Camp Hill (see Map 7.2). There were a mill dam and a small wharf both located near the gap between Camp Hill Marsh and Smith's Hill (see Map 7.2). Smith's Hill was cut level to fill in the marsh (area 'EB1A' in Map 7.3) between it and Camp Hill.

By the end of 1835, the East Boston Wharf Company was in the process of

constructing a wharf (wharf '1' at the lower left corner in Map 7.3) twelve hundred feet in length and three hundred ten feet in width. The wharf had a dockage of one hundred feet on each side. The side walls of this wharf were made of solid granite of an average thickness of seven feet and the space in between was filled with earth.

A seawall (seawall 'A' in Map 7.3) made of granite was constructed in the 1840's or 1850's. It started from Western Wood Island and extended in a southwesterly direction to today's Porter Street protecting a large piece of marsh and flats, about ninety-five acres, from the tidal water.

The Boston Revere Beach and Lynn Railroad (see Map 7.3) was built in 1870's. The railroad ran over flats by bridges supported on piles (Bailey, 1879). During construction, the inner part of the hills (see Map 7.3) on Wood Island was cut and it is very likely that the cut material was dumped onto the marsh and flats next to the hills (area 'EB2A' in Map 7.3).

7.3 Wharf and Pier Development

During the period 1840 to 1885, many wharves were built along the west and south sides of the Noddle's Island. The wharf development is shown in Map 7.3 with 1851 wharfline in solid line. 1880 wharfline is shown as dotted line in addition to that of 1851.

From a report (Massport, 1979) concerning the redevelopment of an East Boston site, the types of construction for several piers (see Map 7.4) are briefly described:

Wharf 2 (605ft x 390 ft ; 5.4 acres) - concrete filled steel pipe pile with concrete deck; 180 ft timber pile, concrete decked bulkhead wharf at inner end on the northwest side.

Wharf 3 (610 ft x 252 ft ; 4.5 acres) - timber pile, timber deck; 250 ft timber bulkhead at inner end on the southeast side.

Wharf 4 (780 ft x 240 ft ; 4.3 acres) - timber pile, concrete deck extending from concrete retaining wall with unspecified solid fill in center and 250 ft bulkhead on the southeast side.

Wharf 5 (513 ft x 40 ft ; 0.77 acre) - timber pile, timber deck.

The above information gives a general idea of the structure of wharves in East Boston. Usually, a wharf has a timber or concrete deck supported by piles of the same material. For some wharves, such as wharf 4, a retaining wall was constructed along its boundary and filling material was placed inside.

7.4 Filling between 1885 and 1915

During the 1890's, the East Boston Company was busy with fill operations. Two areas marked 'EB1' and 'EB2' (see Map 7.3) were reclaimed. Earth from the north side of Eagle Hill was cut and used to fill these two areas. The city also assisted the filling process by dumping cinders and ashes as well. Another piece of marshy area marked 'EB3' (see Map 7.3) was used as a dump site and similar materials were deposited by the city as those in areas 'EB1' and 'EB2'.

7.5 Logan Airport

Before the airport was constructed, most of the area which it was to occupy was covered with a surface layer of very soft organic silt-clay averaging five to ten feet in thickness. Directly beneath this 'harbor silt', was a thin layer of sand followed by the typical Boston Blue Clay. The clay started at an elevation of about ten feet below mean low water and went down to a depth of around a hundred feet below mean low water (see Fig. 7-1).

7.5.1 The 1910's to 1930's

In 1923, the airport was a field of 189 acres (area 'EB4' in Map 7.3) with two landing strips, 1500 feet by 2000 feet, forming a T. The airport was bounded by earth dikes 'A2' and 'A1' on the east and west and bulkheads 'B' and 'A' on the north and south respectively (see Map 7.3). Bulkhead 'A' was built under two contracts in 1916 and 1919 with a total length of 3800 feet running along the south boundary; it also formed the southern boundary of area 'EB5'. Bulkhead 'B' had a length of 2500 feet on the north boundary and was built in 1921.

The 189 acres of land was created mainly by mud dredged from Boston Harbor by hydraulic dredging. The main source of filling material was the central basin (see Map 7.3). The basin was later used as a rehandling basin. Materials dredged from some other parts of the harbor around East Boston were also used. Some other minor sources of materials are: (i) Mystic River - the channel between Mystic Wharf and Charlestown Playground was dredged, (ii) Chelsea Creek - material was excavated by scoop dredge. In addition, a certain amount of fill

containing some broken stones was dredged at Weymouth Fore River and dumped in the area north of Governor's Island.

For an area to the east of the 189 acre airport field (area 'EB5' in Map 7.3), filling operation began at about the same time using similar sources of filling materials and methods as for area 'EB4'. Bulkhead 'C' with a length of about 1900 feet was built on the southwesterly side of the central basin (see Map 7.3). This bulkhead was built so as to prevent the filling material from escaping into the central basin. In 1931, further development of area 'EB5' took place (see Map 7.3). Bulkhead 'D' was built to connect bulkheads 'B' and 'C'. Earth dikes 'E' and 'F' were constructed with materials excavated from a channel next to the central basin. The channel was 200 feet wide, 25 feet deep, and it connected to deep water outside the easterly end of Governor's Island. Its approximate location is shown by dotted lines in Map 7.3. Additional dredging from the westerly end of the central basin was also used to construct earth dike 'F'. Area 'EB5' was filled with material dredged hydraulically from two regions marked 'D' in Map 7.3. These areas were dredged to nine feet below Mean Low Water.

For both 'EB4' and 'EB5', the filling materials dredged was mainly a mixture of clay and mud plus some sand and silt. When first placed, it was allowed to settle and dry out for periods ranging from a few months to four years. The dredged material was covered with two to three feet of dry fill composed of gravel and sand and then surfaced with about one foot of cinders. In the initial phase of filling, the soft fill consolidated under its own weight and that of the dry fill. During the first

few years, problems developed at certain localized spots, evidently where pockets of silty material had collected and the depth of overburden of solid fill was not sufficient to bridge over the soft area. In such cases, the heavier fill sank into the soft material, the latter appearing on the surface, and the affected area settled. Where this problem occured, new solid fill, usually cinders, was used to fill the depression and stabilize the area.

7.5.2 The 1940's

During the years 1943 to 1947, the largest piece of land was added to the airport, a total area of over two thousand acres, bringing the airport nearly to its present size. Bulkheads were built defining the outlines of the new airport land (area 'EB6' in Map 7.4). Over forty million cubic yards of material was dredged hydraulically from adjacent harbor areas and pumped through pipelines onto the site. Most of the dredged material consisted of Boston Blue Clay. Beside dredging from the surrounding water, the considerable hill, a drumlin, of Governor's Island was levelled and used as fill. Rocks and earth were trucked in and dumped onto the site. Area 'EB6' consisted of former ship channels and dredged areas, such as the central basin and the two 'D' areas in Map 7.3, complicating the subsurface conditions.

The hydraulic fill consisted of balls of clay varying from pebble to head size which were laid down in a matrix of semi-fluid clay. Even though these pebbles and balls consisted of medium-plastic clay, the mass as a whole was rather unstable due to the matrix of semi-fluid clay. This hydraulic clay was quite different from a

natural clay. It was evidently consolidated by partial drying when the surface of the clay was above sea level several thousand years ago. From detailed tests on boring samples (Casagrande, 1948), it was found that the clay in the clay balls was preconsolidated to a considerable greater stress than the stress it was subjected when used in the fill. It was concluded that compression of the clay fill would be largely due to plastic deformation of the clay balls and consolidation of the soft clay matrix between the clay balls rather than primary consolidation of clay balls themselves. The consolidation rate thus was considerably faster than the primary consolidation of a natural clay.

Airport runways were made of five feet of pavement and base on top of the hydraulic fill. The pavement and base consists of bituminous layer, crusher run stone layer and sand-gravel layer from top to bottom. The substantial thickness of pavement and base was used to consolidate the soft matrix between the clay balls and to increase the bearing capacity.

7.5.3 The 1960's to 1970's

Bird Island Flats (area 'EB7' in Map 7.4) with a surface area of one hundred and ten acres was filled in the late 1960's and early 1970's. Before being filled, the eastern end of the site was a disposal area for harbor dredging in the mid 1960's. The material dredged was mainly organic clayey silt which was dumped from barges onto this area. A rock dike (dike 'G' in Map 7.4) was built along the south and west perimeter to contain the filling material within the site limits. Granular material was used to fill this area. During the initial dike construction, a roadway was built

across the middle portion of the site from north to south separating the site into two parts (see Map 7.4). The roadway was subjected to heavy traffic and thus had better compaction than the rest of the area.

In both the east and west parts, filling operations started from the north corner with filling material pushed into the water. The material was obtained from many different borrow areas throughout eastern Massachusetts. It consisted primarily of fine to medium sand with traces of gravel and silt.

Because of the loose and variable nature of the granular fill, a heavy vibratory roller was used to compact it. This helped developing a more uniform density in the upper ten feet of filling material. In areas where buildings were to be located, vibratory rolling was not sufficient and deep densification was required. Deep densification can reduce differential settlement and the liquefaction potential of loose sands under earthquakes. Deep densification could only be used in areas where no compressible organic soils or soft clays were found underneath. Several methods were recommended (Fay, 1980):

(i) Dynamic Consolidation - compacting soil by dropping a heavy weight from a large height.

(ii) Vibroflotation and (iii) Terra-probe - compacting soil by vibration.

(iv) Compaction Piles - pipes closed at the bottom by a plug of gravel are driven into the soil. Additional gravel is rammed down by a high energy drop hammer and the pipe is gradually withdrawn.

The report (Fay,1980) does not state which of these methods was used.

Another filled area as the airport (area 'EB8' in Map 7.4) was originally a piece of mud flats exposed at low tide. It was reclaimed when one of the runways was extended to Wood Island in 1967. A rock dike (dike 'H' in Map 7.4) was built on its northeast side so as to protect the site from the tides. Most of the filling material was gravel brought in by trucks and deposited in several layers. At the beginning of the filling process, a thin layer of gravel about two feet in thickness was spreaded by light bulldozers. Then, another three or four feet of gravel was dumped from trucks and pushed out onto the area. With a total thickness of about five to six feet of gravel on top of the mud/organic silt, the gravel surface was about at the elevation of high tide. Sand drains were used to speed up consolidation of the mud and clay underneath the gravel fill! Thousands of steel pipes, fifteen inches in diameter, forty feet long and spaced eight feet from center to center, were driven through the gravel fill layer into the soil underneath. The soil inside the pipes was replaced by sand and the pipes were removed (see Fig. 7-2). Additional gravel was deposited to a total thickness of over twenty feet to further accelerate settlements. It took about one year for the situation to become stable, at that time the mud lying underneath the gravel had undergone ninety percent of its total settlement.

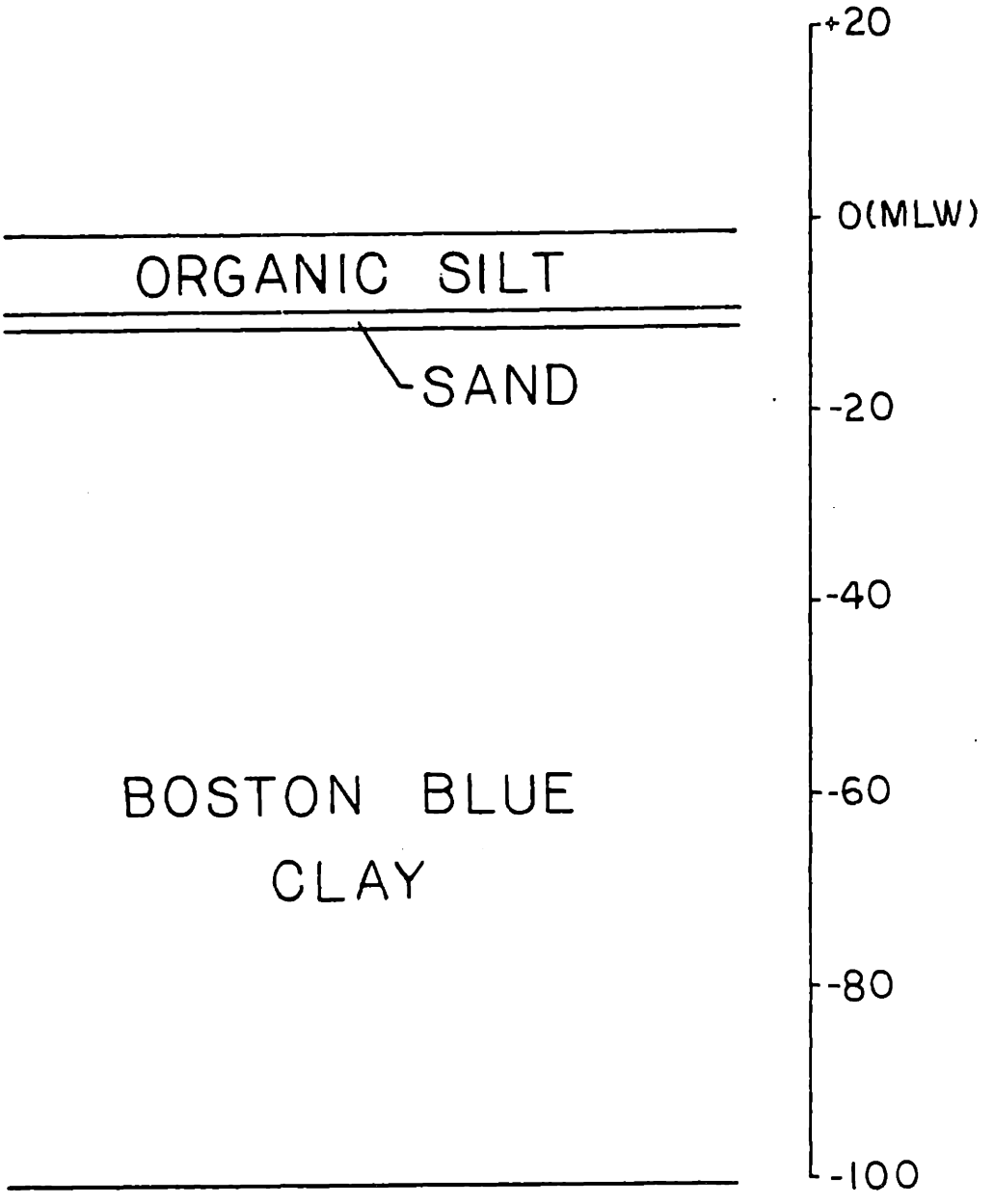

Figure 7-1: Typical Profile of Prefill Logan Airport

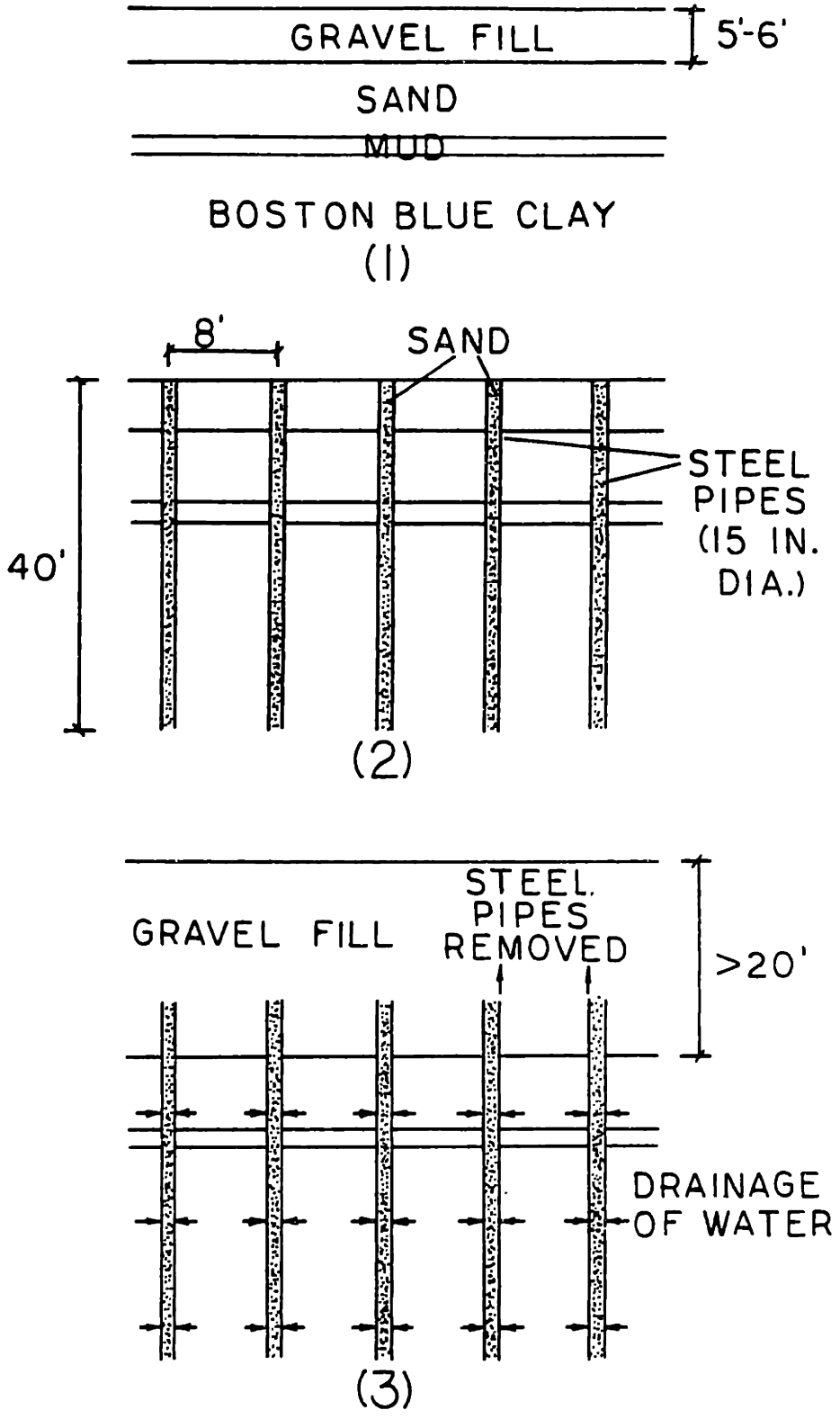

Figure 7-2: Procedure of Landfill in area 'EB8'

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Chapter 8

South Boston

8.1 Introduction

South Boston was originally only about half of the present size. The original shoreline,i.e. high water line, is shown in Map 8.2. The whole piece of land lying north of the original shoreline, about seven hundred and fifty acres, was reclaimed from the sea. Before the land was filled, it was a large area of flats. Castle Island was isolated at the eastern end of South Boston while today it is connected to the mainland with the flats in between being filled. The original low water line, the six feet, the twelve feet and the eighteen feet lines below low water are also shown in Map 8.2 (Greenleaf, Simmon, 1850). Half of the filled area in South Boston is above the low water line and the rest is below the low water line. Several prefill cross-sections across the flats are drawn in Fig. 8-1 to Fig. 8-5. These cross- sections are based on the map of Parrott, George B., 1849. Clay and mud occupied a large portion of the flats, and sometimes gravel was found. Two special areas 'slate ledge' and 'oyster bank' are shown in Map 8.2.

South Boston did not have much early wharf construction except that of Boston Wharf. The 1866 wharfline is shown in Map 8.2. Most of the present wharves and docks were built together with or after the filling of flats. Filling began at the northwest boundary of the flats, i.e. at Fort Point Channel, in the 1870's. The filling progressed in a southeasterly direction until Castle Island was

connected with the South Boston mainland. The filling lasted for over forty years. Most of the filling material was clay excavated from the harbor. An area marked as 'SB12' (see Map 8.4), the latest land reclaimed in Boston, was filled in the late 1970's and early 1980's.

8.2 Boston Wharf Company and Adjacent Flats

Boston Wharf Company was established in 1836. Much of the first filling material was removed from a small drumlin known as Nooks Hill (see Map 8.2). Little by little it was leveled and conveyed to the Boston Wharf domain. A seawall twelve feet high was erected along the boundary of the wharf. When the wall was completed and the space within it partially filled, a stone wharf laid on piles was built. In 1850, the Boston Wharf (area 'SB1' in Map 8.3) was opened for business. Early in the 1830's, Fort Point Channel was excavated and allowed navigation. The excavated material was used to fill South Cove (see Chapter 9, South Cove and South Bay).

In the early 1850's, the New York and New England Railroad embankment (see Map 8.3) was built across the flats outside the Boston Wharf. The embankment was made of solid fill but no information on the type of material used was found. It is very likely that the solid fill was gravel which was very commonly used at that time.

An area north of Boston Wharf (area 'A' in Map 8.3) was shown as filled land according to the map prepared by Hewins, E.H., 1869. It is suspected that this area

was filled in the late 1850's or 1860's with similar filling material as used in Boston Wharf.

The great Boston Fire in 1872 burned down many houses in Boston Peninsula, specifically in the area between Summer and Pearl Streets from Washington Street to the harbor. Enormous quantities of brick, plaster and miscellaneous rubbish were poured, load by load into empty spaces of the Boston Wharf property (area 'SB2' in Map 8.3) between Northern Avenue and West First Street.

In the 1870's, three types of seawalls were built forming the boundary at the northern corner of South Boston flats. A light seawall (seawall 'A' in Map 8.3) was built east of Fort Point Channel, starting from south of Eastern Avenue (today's Summer Street) to north of Northern Avenue. A heavy seawall (seawall 'B' in Map 8.3) ran from the end of the seawall 'A' around the curve to the first dock. Another heavier wall (seawall 'C' in Map 8.3) was constructed between the first and second dock. The walls surrounding the two docks (seawall 'D' in 8.3) were similar to the light seawall. The structure of each of the walls is described in the following paragraphs.

Construction of the seawall 'A' began in 1873. The seawall was built on a pile foundation. Piles were driven in rows of five. Each row had a width of nine feet. There was a spacing of two and a half feet from center to center between rows. The piles with a diameter not less than ten inches were driven down into a hard stratum of clay and their heads sawed off at two and a half feet below low water. The in-situ material was excavated two feet below the heads of the piles and was

refilled with stone ballast or oyster shells. Two layers of spruce plank twelve inches wide and three inches thick, lying at right angles to each other were spiked onto the heads of the piles. The wall was nine feet wide at the base, five feet wide at the top, eighteen feet high and with a true batter front and rear. The top of the wall is at grade sixteen. It was built of granite stones from eighteen inches to two feet thick, with sufficient headers to secure the stability of the wall. It was well bonded and pinned throughout. The rear of the wall was ballasted with oyster shells. The ballast was two feet at the top and sloped down at forty-five degrees to the base level of the wall. The dock wall/seawall 'D' was of the same structure as the seawall 'A' except for a wooden platform supported on piles built along the front. A typical cross-section of seawall 'D' is shown in Fig. 8-6.

The heavy seawall 'B' west of the dock was constructed in 1875 and 1876. It was seven hundred and sixty-five feet in length. A trench was first excavated at the location of the wall. The trench was forty-five feet wide and twenty-three feet below low water or down to the hard clay if it was not reached at that depth. The trench was filled with broken quarry stones not less than seventy-five pounds in weight. The stones were deposited in layers of not over four feet per layer, and each layer was placed and levelled off by divers with bars. This trench filling was forty-five feet wide in the bottom three feet. Then, it sloped inward on each side to eighteen feet wide at a depth of eleven feet below mean low water. It was levelled off at the top with smaller chips of quarry stone so as to receive the wall. The wall was built of granite stone. It was divided into upper and lower portions. The lower portion was from the base of the wall, i.e. at eleven feet below low water, to one

foot below low water. The base width of the wall was fourteen feet and the width was eleven feet four inches at one foot below low water. Granite stone was laid in courses of two feet rise each by divers. The courses are laid alternately, entirely with headers and stretchers. Each stone was at least four feet, and not more than ten feet long, at least eighteen inches wide, and with exactly two feet rise. In the upper portion from one foot below low water to the top at grade sixteen, each course consists of headers or stretchers laid in cement mortar. The thickness at the bottom of this portion was nine feet eight inches and at the top it five feet. The back of the wall was ballasted with clean gravel, cobbles or oyster shells, resting at a slope as steep as they could stand or at forty-five degrees. A typical cross-section of seawall 'B' is shown in Fig. 8-7.

The heavy seawall 'C' between docks was constructed in 1876 and 1877. It was thirty-nine feet high eighteen feet wide at the base and five feet at the top. It had a straight back and a batter of one to three on the front side. The wall rests upon a foundation of broken stone laid in a trench of thirty-six feet width and three feet depth. Like seawall 'B', seawall 'C' was built of granite laid without cement mortar below low water and with cement mortar above low water. The ballast consisted of gravel, oyster-shells or rip rap. A typical cross-section of the heavy seawall 'C' is shown in Fig. 8-8.

The area behind the walls (area 'SB3' in Map 8.3) was filled with material dredged from the Fort Point Channel and the harbor and was mainly composed of clay. The mouth of Fort Point Channel was dredged (marked as 'E' in Map 8.3).

Dredging began at the middle portion of seawall 'A' where it was twelve feet below mean low water. It then sloped down along the channel and at a point about midway of seawall 'B', the depth was twenty-three feet below mean low water. The portion of this excavated channel opposite seawalls 'A' and 'B' was four hundred feet wide. Passing eastward the width gradually contracted to about two hundred feet before arriving at the first dock. Near the entrance to this dock, it was widened again to a width of four hundred feet, with a depth of twenty-three feet at low water. From this point, a channel was dredged about two hundred feet wide and connected to the main ship channel. Another considerable amount of material was taken from a shoal off the end of Long Wharf.

The clay dredged from the channel and harbor was generally so stiff that the use of a heavy scoop dredge was required. It was then loaded onto scows which floated onto the flats at high water and the clay was dumped. When the filling was raised too high for the scows to enter, they discharged their content in front of the walls. A clam-shell dredge was used to lift the material over the wall and dropped it into small tramway cars, handled by a light locomotive. The tramways extended over the partially filled flats, and were supported on pile trestles. The car had side boards hinged at the top, with bottoms sloping down on each side from the center, so that when the side boards were raised the clay slipped out on both sides. The repeated handling had reduced the clay to a semi-fluid material, so that it spread for several hundred feet on either side of the tramway, thus avoiding the construction of many lines of trestles. The ridges left alongside the tramway were removed by wheel-barrows to other lower areas. The clay was deposited to grade

thirteen. On top of the clay, three feet of gravel was placed. Part of the gravel was same as that used for ballast which was brought by scows from dredgings near the mouth of harbor, and was dumped, hoisted over the wall, and distributed in the same manner as the clay. A larger portion of the surface gravel was brought in from Readville by rail, about nine miles, on the line of the New York and New England Railway.

8.3 Central Part of South Boston Flats

Two areas, 'SB4' and 'SB5' (see Map 8.3), are discussed in this section. 'SB4' covers an area of one hundred acres and 'SB5' is seventy-five acres. Both areas were filled under many contracts with different companies. 'SB4' was filled in between 1880 and 1888, 'SB5' between 1887 and 1895.

8.3.1 Area 'SB4'

A bulkhead was built along the northern boundary of area 'SB4' (bulkhead 'A' in Map 8.3) to retain filling material. Clay was deposited along the front of the bulkhead to secure and strengthen it. This clay was dredged from Bird Island Shoal in East Boston. It was dumped from bottom scows or shovelled from deck scows wherever the scows could not reach. The area was divided into three portions: northeastern portion of sixty-one acres, central portion of thirty acres and southwestern portion of nine acres.

The northeastern portion was filled with material dredged from the harbor in the vicinity of South Boston Flats. A large amount of material was obtained from

shoals outside the Harbor Commissions Line to the main ship channel (area 'F' in Map 8.3). These shoals were excavated to a depth of twenty-three feet. Part of the material excavated from area 'E' was also used in filling this portion of area 'SB4'. Up to 1884, about seventy-two acres had been added to the deep water area of the harbor in connection with the work at South Boston. The material dredged was mainly clay which was filled to grade thirteen above mean low water and then raised to grade sixteen by a layer of gravel filling.

The central portion of 'SB4' was a dumping ground for material excavated from other parts of the harbor. Usually, miscellaneous dredgings done in Boston upper harbor by different parties were dumped here. Thus, the filling material could have a wide range in characteristics because of its varying sources. For both the northeastern and central portions, transportation, handling and dumping of filling material was similar to that used in area 'SB3'. The dredged material was first dumped directly from scows. When the material raeched a level that the scows could not enter, it was deposited at receiving or elevating stations, then it was hoisted by a clam-shell into cars, and conveyed by locomotives over tramways to the place of final deposit, where it was levelled to the required grade.

The southern portion of 'SB4' was a strip along the original shore line and it was a dumping place for ashes and other refuse materials obtained from the city. Usually, this material was carried in and dumped by small carts.

8.3.2 Area 'SB5'

A wooden bulkhead was built along the northeastern and southeastern sides of area 'SB5' (bulkhead 'B' in Map 8.3). Its total length was about two thousand and five hundred feet and it reached a height of grade fourteen. Construction began in 1890. The bulkhead was built of piles, driven six feet apart between centres. The piles were not less than ten inches in diameter at the top and six inches at the bottom. These piles were driven at least twelve feet into the hard clay. Three stringers of spruce timber were bolted onto the face of the piles. Spruce planks three inches thick were driven vertically one or two feet into the earth, and well spiked to the stringers. The bulkhead was used to retain filling material placed behind it.

A seawall was built on the southern boundary of area 'SB5' (seawall 'E' in Map 8.3). It was constructed at about the same time as bulkhead 'B'. The wall was built of granite stones supported on pile foundation. A trench of fourteen feet width was first excavated to a depth of three feet below mean low water. Excavated material was deposited behind the trench. Spruce piles were driven in rows of five with equal spacings across the wall and the distance between end piles was eight and a half feet. The rows were spaced at two and a half feet on centres. Piles of diameter not less ten inches were driven twelve feet or more into the hard clay, and where possible, not less than twenty-three feet below mean low water. The space in the trench around piles was filled with broken stones. All piles were cut off at mean low water and covered with spruce plank which was spiked to the heads of piles. Granite stones one to three feet thick were used to construct the

wall. The wall is similar to the seawall 'A' built along the Fort Point Channel. After completion of the wall, about six thousand cubic yard of clay was dredged from the harbor near East Boston and placed in front of the wall but the exact dredged area was not found.

'SB5' was actually a continuation of 'SB4' and some material from the same source for filling 'SB4' was used in 'SB5'. A significant amount of filling material was obtained from a channel named 'reserved channel' and a temporary channel which connected it to the main ship channel (see Map 8.3). The channels were excavated in several stages. In 1889 to 1891, the reserved channel was excavated to sixty feet width and twelve feet depth, and the temporary channel was excavated to sixty-five feet width and eight feet depth. In 1892 and 1893, part of the reserved channel was widened to four hundred feet and the remaining portion widened to one hundred and ten feet. The temporary channel was enlarged to one hundred and fifteen feet. Scows were used to transport the excavated material and to deposit it in the area of 'SB5'. Most of the excavated material was clay. This process continued for several years until most of the area was filled to a level which made it impossible for the scows to enter the area. Then, the hydraulic dredging method was introduced. The hydraulic dredge consisted of a scow containing a large rotary pump and cutters for loosening the material. The material was sucked into the pump together with a large quantity of water and forced ashore through a line of pipes. When discharged upon the area to be filled, the material settled and the water flowed off through sluice-ways. By this method, very little work was required in completing the surface grade. Some of the material dredged from the

reserved channel consisted of a large number of stones and small boulders mixed with the harbor clay.

Some other sources of filling materials were used. In 1892, about two hundred thousand cubic yard of material was dredged near Mystic Wharf in Charlestown which consisted mainly of sand with some stone and clay. The material was used to fill in the east corner of area 'SB5'. It was handled by a combination of processes. The material was first transported by scows and then placed in a hopper by using a clam-shell dredge. From there, a hydraulic dredge was used to pump the material to the place of deposition. Some material was dredged from Chelsea Creek but no detailed information could be obtained on how this material was handled.

City ashes, refuse, earth and waste materials contributed part of the filling material. They were dumped in the E Street extension (see Map 8.3), along the northern portion of bulkhead 'B', and some low spots in the area. Some of the better material was used in surfacing part of the filled land. The remaining area was surfaced by a three feet layer of clean coarse gravel to a grade of sixteen feet above low water.

8.4 Commonwealth Pier and Pier 6

Commonwealth Pier and Pier 6 are the two biggest piers in South Boston. Commonwealth Pier (area 'SB6' in Map 8.3) was constructed during the late 1890's and early 1900's. The pier is four hundred feet wide and twelve hundred feet long. It consists of a central solid fill portion enclosed by a granite seawall which is

supported on a pile foundation. A cross section of Commonwealth Pier is shown in Fig. 8-9. A trench was first excavated at the location of the seawall and the excavated material was used for filling the central portion of the pier. Rows of piles were driven into the hard clay. Surrounding the piles, a rip rap of stone and gravel was placed which sloped down to the dock to a depth of thirty feet below mean low water. A granite wall was built on top of the piles and stones. The wall encloses an area of three hundred feet by eleven hundred and fifty feet. Stone and gravel ballast was placed behind the wall. Outside the wall, a platform fifty feet wide was constructed. The platform was supported on piles driven through the rip rap slope into the hard clay.

The area of Commonwealth Pier inside the wall was filled to grade fourteen. The material excavated from preparing the foundation was used as filling material. Additional material dredged from docks on either side of the pier and in front of the pier was also used. Hydraulic or suction methods were not allowed in filling the area. It is suspected that the traditional technique, i.e. scows and clam-shell dredges, was used. After the material was filled to grade fourteen, two feet of gravel was placed on top as surfacing material.

Pier 6 (area 'SB7' in Map 8.3) is also a solid fill pier. It is located three hundred feet to the east of Commonwealth pier. It was constructed in the 1900's and has dimensions of three hundred feet width by twelve hundred length. A granite seawall was constructed along the pier's boundary. A cross-section of Pier 6 is shown in Fig. 8-10. Again a trench was excavated at the location of the seawall

and a layer of stone was placed in it. The stone layer was finished with a slightly sloping surface towards the pier and the granite seawall was build on the stone layer. No pile foundation was used. The rest of the structure is similar to that of Commonwealth Pier. Filling material was dredged from the docks surrounding the pier.

Another granite seawall along Northern Avenue (seawall 'F' in Map 8.3) was constructed. It is similar to the seawall of Commonwealth Pier. A section of seawall 'F' is shown in Fig. 8-11.

8.5 North of Reserved Channel

The filled land north of Reserved Channel includes areas 'SB8' and 'SB9' (see Map 8.4). The former was filled in the 1900's and the latter in the 1910's together with construction of a dry dock.

'SB8' was connected and located to the southeast of 'SB5', and it covers a surface area of twenty-six acres. A bulkhead (bulkhead 'C' in Map 8.4) was constructed along the northern boundary of 'SB8' which formed an extension to bulkhead 'B' of 'SB5'. Bulkhead 'C' was constructed in 1900 and it had a length of eleven hundred feet. The next year, a seawall was built on the southern side of the area (seawall 'G' in Map 8.4). The seawall is a structure similar to seawall 'E'. Specifically, seawall 'G' is a granite seawall supported on pile foundation. In 1903, another bulkhead (bulkhead 'D' in Map 8.4) was constructed. It connected bulkhead 'C' to seawall 'G' and 'SB8' was thus completely enclosed.

'SB8' was filled with material dredged from two areas in the harbor. (i) The temporary channel was widened by fifty feet on the northern side along its whole length to the main ship channel. (ii) An area to the north of areas 'SB5' and 'SB8' was also excavated. The area is marked 'G' and shown by dotted line in Map 8.3. It surrounded several small piers and consisted of a channel extending into the main ship channel. The channel extending into the main ship channel was later partially occupied by pier 4 (see Section 8.7, Latest Filling). The area was excavated to eighteen feet below low water. Material from these two areas was used in filling 'SB8'. At first, the filling material was dumped directly from scows. When 'SB8' was filled up to a level that the scows could not float into it, the material was rehandled by a hydraulic dredge.

Filling of 'SB9' was closely related to the construction of the dry dock (see Map 8.4). In 1915, excavation of the dry dock began. Two steam shovels were used. Excavated material was transported by cars running on rails and dumped into adjacent flats, i.e. area 'SB9'. In addition, the approach channel to the dock was excavated. A cofferdam was constructed to close the eastern end of the site so that the dry dock area could be dewatered. Clayey material was used to construct the cofferdam, and additional material such as gravel and stone was used later on. The wall of the dock was constructed of granite stone. At a later stage of excavation, rock was found underneath the earth and blasting was required to remove the rock. In 1917, seventy-eight thousand cubic yard of earth and sixty-six thousand cubic yard of rock were excavated. The dock was completed in 1919.

The site chosen for the dry dock (see Map 8.4) made relocation of the reserved channel necessary. The temporary channel was filled and the reserved channel extended straight into the main ship channel. The relocated channel was excavated three hundred feet wide and thirty feet deep. Excavated material was placed onto the flats in area 'SB9' by the hydraulic dredge method.

8.6 South of Reserved Channel

The land south of Reserved Channel is the City Point area which consists of area 'SB10', i.e. Marine Park, and area 'SB11' (see Map 8.4). Marine Park was filled in the late 1880's and early 1890's. Considerable amount of material was dredged from Pleasure Bay (see Map 8.4) and dumped onto the flats of 'SB10'. The filling material consisted of clay and gravel but the clay portion might have been washed away by the action of the waves (Department of Parks, 1887). Iron pier (see Map 8.4) was constructed from the park, and it enclosed the southern side of Pleasure Bay. The pier was supported on a foundation of concrete columns. In 1890, a pier-head (see Map 8.4), a pear-shaped island built of gravel was constructed at the end of the pier. Its outer surface was protected by a sloping wall of ballast and rip-rap which was surmounted by a parapet of cut granite. The artificial island was supported on a mud foundation and no piles were used.

'SB11' was filled in the late 1910's when the reserved channel was relocated. In 1919, a five thousand feet long bulkhead (bulkhead 'E' in Map 8.4) was constructed on its northern side which prevented the filling material from entering into the channel. A major portion of the material excavated from the reserved

channel was used to fill this area. The excavated material was mainly clay and mud. It is believed that the material was handled by the hydraulic dredge method.

8.7 Latest Filling

Up to the present, area 'SB12' (see Map 8.4) is the latest filled land in South Boston. It is located north of areas 'SB8' and 'SB9'. A site plan is shown in Fig. 8-12. The area was originally occupied by four piers: 1, 2, 3 and 4 (see Map 8.3). These were wooden piers supported on wooden piles. In the late 1970's and early 1980's, area 'SB12' was filled. It consisted of the construction an embankment along its northern and western boundary and the filling of materials obtained from different sources.

NOTE: The four piers were probably built in the 1960's or 1970's but detailed information on their structures wass not found.

Before the construction of the embankment, the piers were partially removed which included the entire pier 4 and the outboard ends of piers 1, 2 and 3. The embankment was constructed on a broken rock foundation. Its outside surface is protected by a rip rap slope. The embankment was subdivided into 'A', along the northern side, and 'B', along the western side (see Map 8.4). Cross-sections of the embankments are shown in Fig. 8-13 and Fig. 8-14.

About one hundred thirty-two thousand cubic yard of rock was used to build the foundation. Onsite blasting of a ledge supplied about seventeen hundred cubic yard of the required material. Location of the ledge is not specified in the report of

Seaport Development, 1980. The rest of the material was obtained from the MBTA Southwest Corridor Project, i.e. the new Orange Line. The stone was a well-graded mixture of gravel and boulders with an uniformity coefficient not less than 3. It had the following gradation:

size	percent passing
15 in	100
12 in	95-100
6 in	45-75
3 in	15-45
1 in	0

Placement of the rock base material was by waterborne equipment which completely stirred the bottom sediment along the alignment of the dike. Thickness of the rock base varied from one to ten feet, with an average of five feet.

The embankments have a width of thirty feet at the top, i.e. at grade sixteen. They have an outside slope of two to one, horizontal to vertical, and an inside slope of three to one. Material used for building the embankments consists of sand and gravel. It has an uniformity coefficient of not less than 6. Below the mean high water, the granular material contains no more than ten percent fines, and above mean high water material of no more than twenty percent fines was used. A borrow site located in Plymouth provided clean sand and gravel for constructing the embankments below mean high water. Material from the MBTA Southwest Corridor Project was used for the portion above mean high water. A total amount of seven hundred twenty-five thousand cubic yard of material was used for the embankments. A drainage layer and pipes were placed in the embankment to prevent the build up of excess hydrostatic pressure behind the embankment. The

rip rap slope outside the embankments is made of stones weighing over one hundred pounds. About sixty percent of the stones exceed five hundred pounds. Thirty-five thousand cubic yard of rock material was used in constructing the rip rap.

Fill placement occurred concurrent with construction of the embankments. Filling material was obtained from different sources: (i) dredging of the berth area north of embankment 'A', (ii) removal of bottom material from the containment area, i.e. the area of 'SB12' behind the embankment, (iii) the MBTA Southwest Corridor Project and (iv) the sand and gravel borrow site in Plymouth. A total amount of 2.3 million cubic yards of filling material was used.

The dredging of the berth area was divided into two stages. The first stage was done prior to the embankment construction and involved excavation of a twenty-five feet wide strip north of embankment 'A' to a depth of thirty-six feet below mean low water. This operation yielded approximately sixteen thousand cubic yards of unclassified material and seventeen hundred cubic yards of blasted ledge. The second stage of berth dredging occurred after the completion of the embankment. It extended the berth area to the main ship channel. The width of dredging varied from two hundred forty to three hundred thirty feet. Dredged material obtained from this operation consisted of eighty thousand cubic yards of unclassified material and fifteen thousand cubic yards of blasted ledge. The main ingredients of the unclassified material is black clayey organic silt and grey clayey sand and gravel. The sand and gravel was placed directly as filling material. The organic silt was stockpiled at a diked storage area which served as a settling pond.

Dewatered organic silt was mixed with clean sand and gravel obtained from Plymouth. The mixture consisted of no more than twenty percent fines and it was used as general fill above mean high water but not below mean high water.

Dredging of the containment area involved the excavation of a mud wave which consisted of fine-grained bottom sediment displaced during the filling operation. About two hundred thousand cubic yard of displaced material was dredged. The material was mainly organic silt. This organic silt was treated the same way as that obtained from the berth area. It was mixed with clean sand and gravel and was then used as filling material above mean high water.

Both the berth area and containment area were dredged by means of clamshells, shovels and buckets. Hydraulic dredging was not used because of the large volume of supernatant water generated and the elaborate collection and treatment system necessary to minimize suspended sediment concentration, and to maintain water quality standards.

The MBTA Southwest Corridor Project provided the largest amount of filling material, about 2 million cubic yard. Most of it was used as filling material within the containment area and some was used in embankment construction above mean high water. It also provided granite blocks for the rock base and the rip rap for the slope of the embankment. The filling material was mainly sand and gravel which consisted of no more than twenty percent fines. The material did not contain excess amounts of organic matter, debris, or other deleterious substances. The Southwest Corridor Project was divided into three major segments, each yielded a different

amount of suitable filling material. Segment 3, i.e. Forest Hills to Jackson Sq., provided 1.3 million cubic yard of material. Segment 2, i.e. Jackson Sq. to Ruggles St., provided 0.4 million cubic yard of material. Segment 1, i.e. Ruggles St. to South Cove, provided 0.3 million cubic yard of material. Fill shipment commenced in Spring 1980 and continued for about two years. The material was trucked directly to the filled area. Placement of filling material employed heavy construction techniques and equipment. In an initial stage, material was placed along the eastern and southern boundary of 'SB12' and it was distributed by bulldozer and front end loader. Once an initial mound occuping the entire water column was established, subsequent filling caused slumping of the active fill slope. Material was pushed forward over the newly placed fill area and incremental cells were formed at the water's edge. A mud wave was displaced at the front of the cell fill. The mud was excavated, mixed with clean sand and gravel and reused as filling material. A cross-section of the filling site is shown in Fig. 8-15.

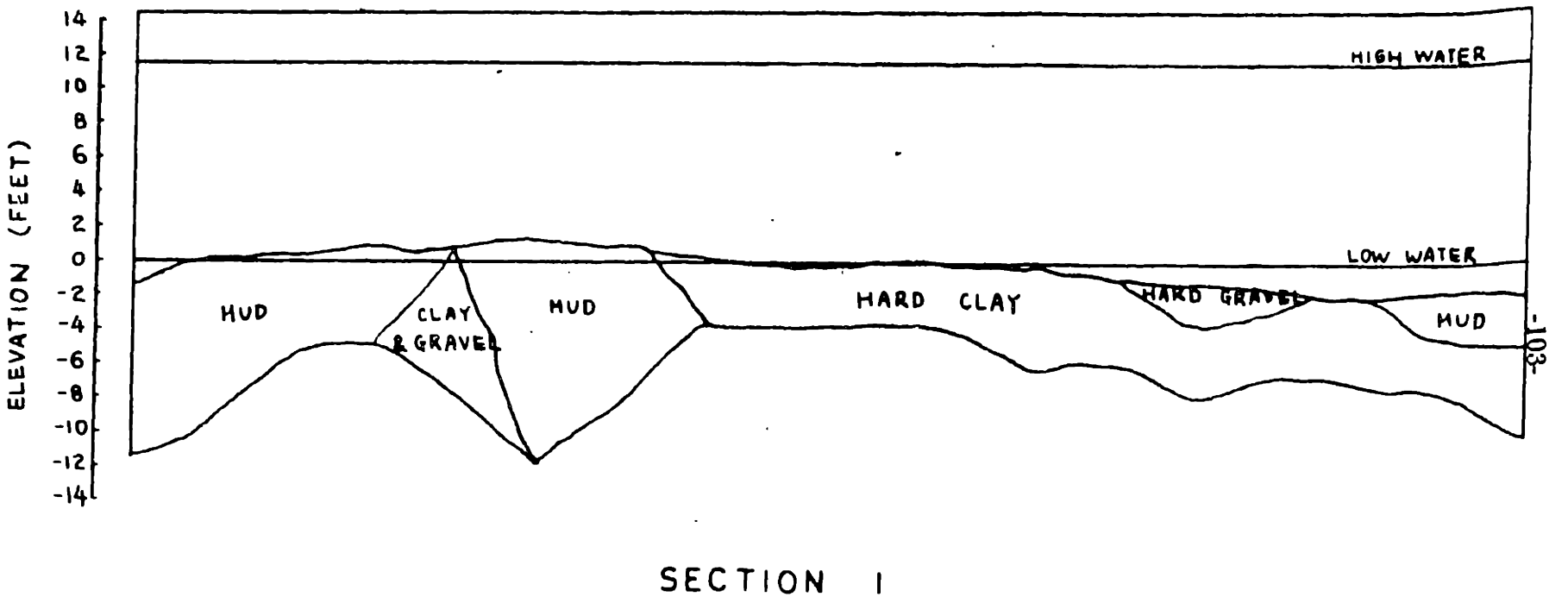


Figure 8-1: Prefill Cross-section of South Boston Flats (Parrott, George B., 1849)

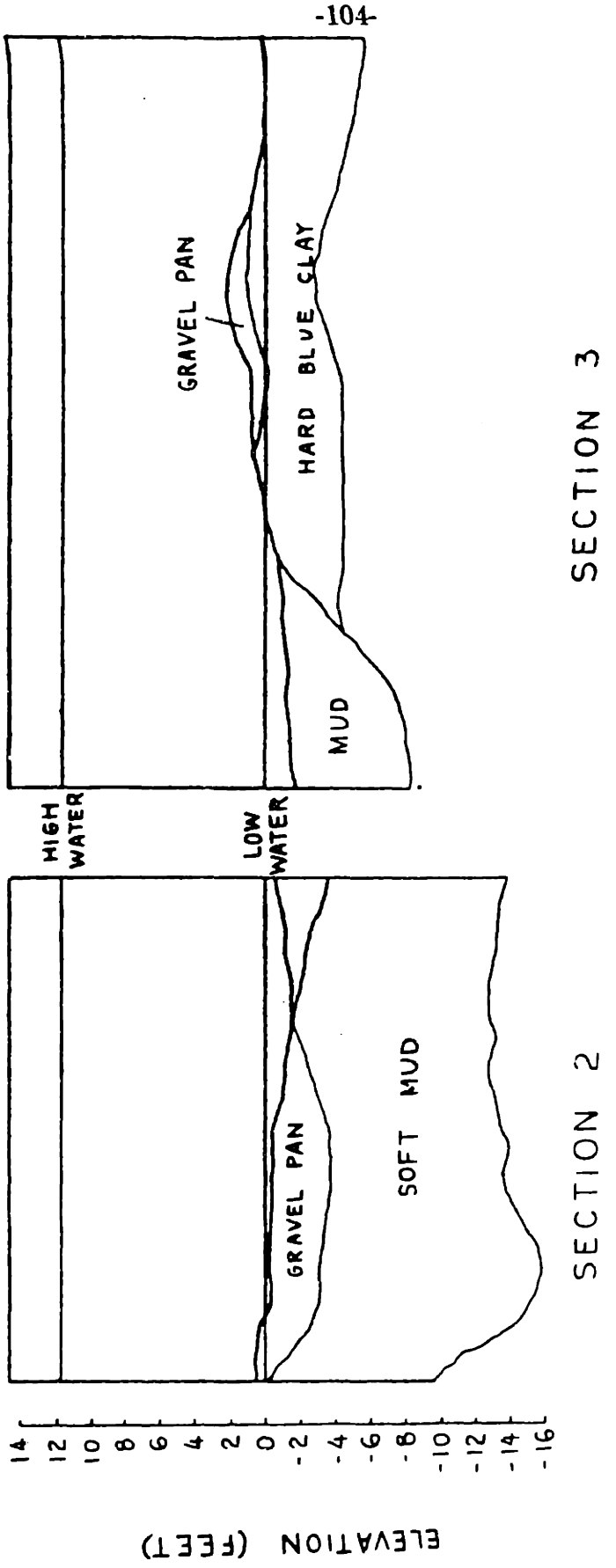


Figure 8-2: Prefill Cross-sections of South Boston Flats (Parrott, George B., 1849)

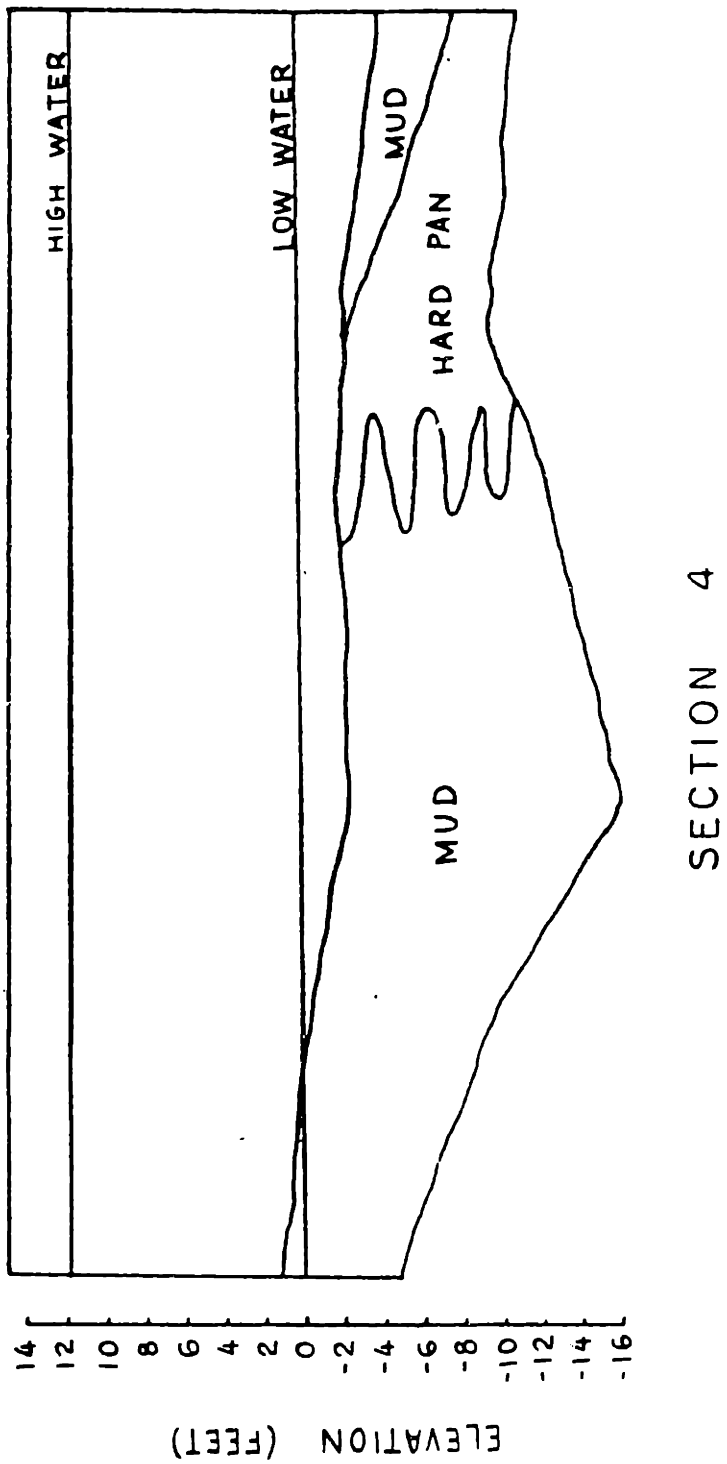


Figure 8-3: Prefill Cross-section of South Boston Flats (Parrott, George B., 1849)

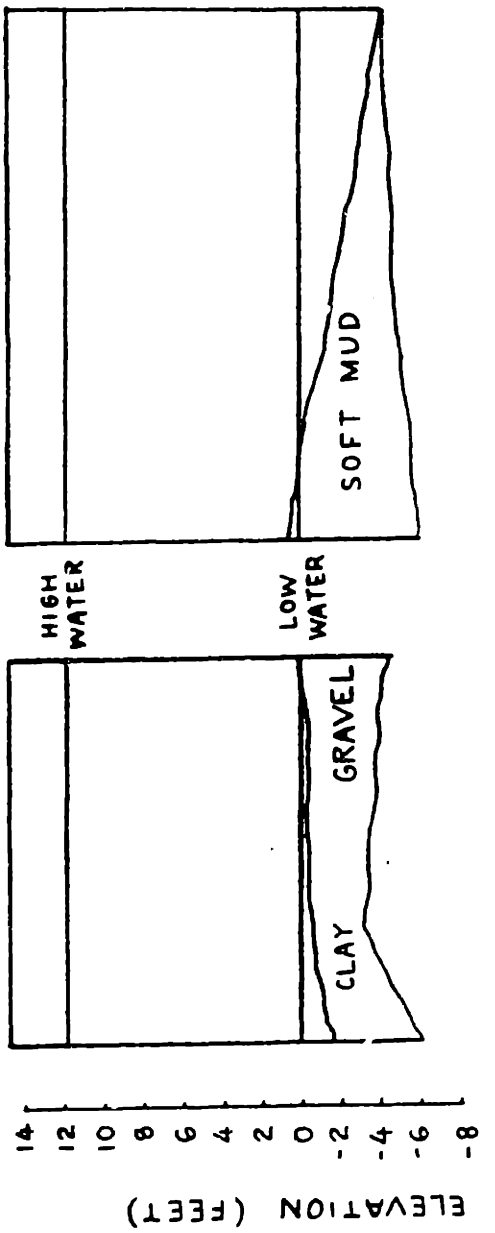


Figure 8-4: Prefill Cross-sections of South Boston Flats (Parrott, George B., 1849)

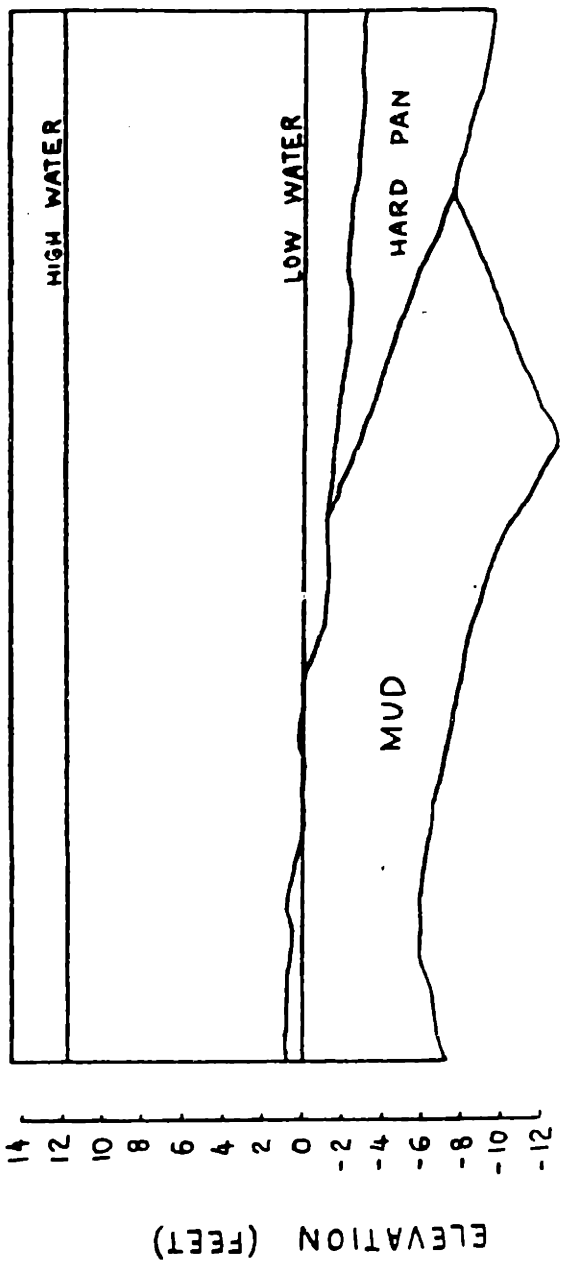


Figure 8-5: Prefill Cross-section of South Boston Flats (Parrott, George B., 1849)

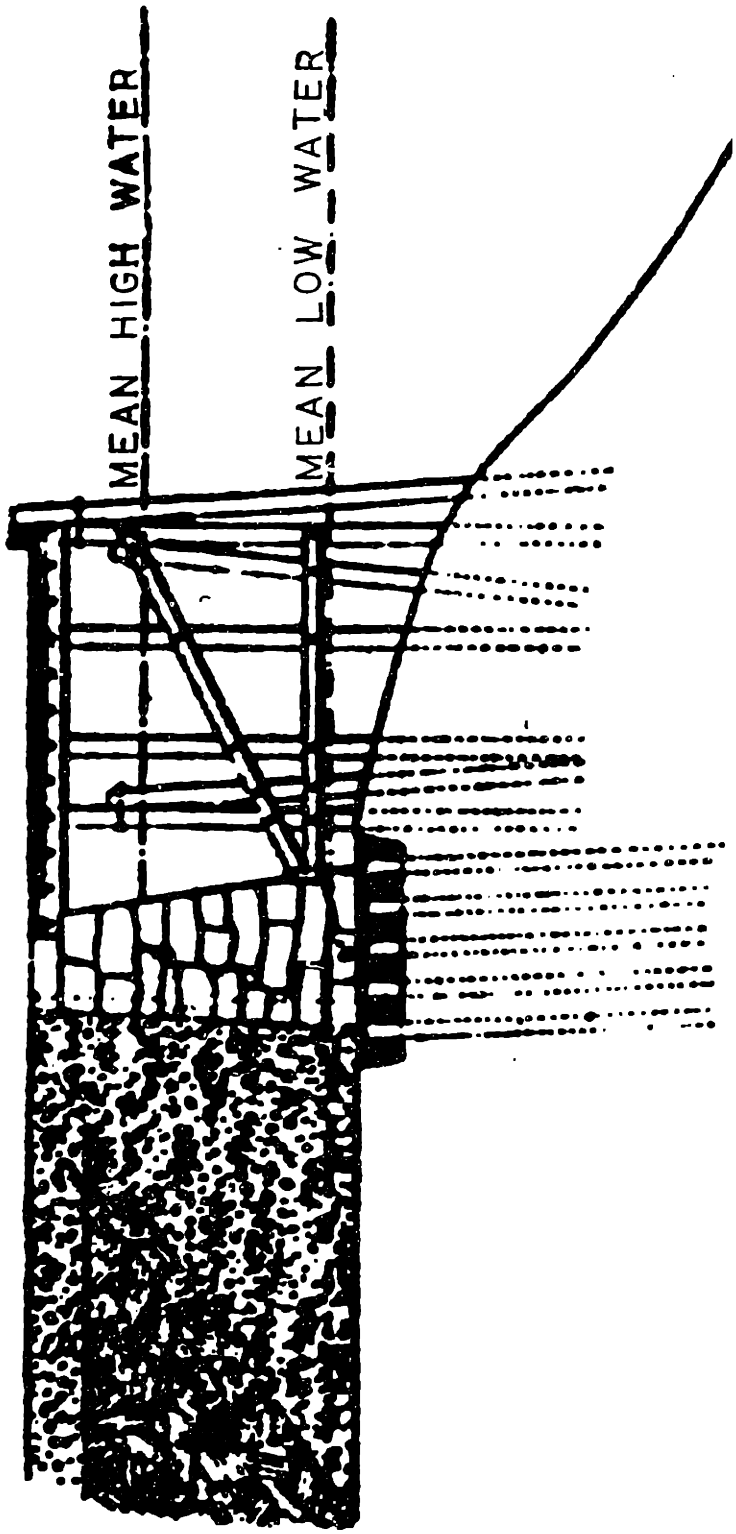


Figure 8-6: Typical Cross-section of Seawall 'D' (Harbor Commissioners of the State of Massachusetts, 1878)

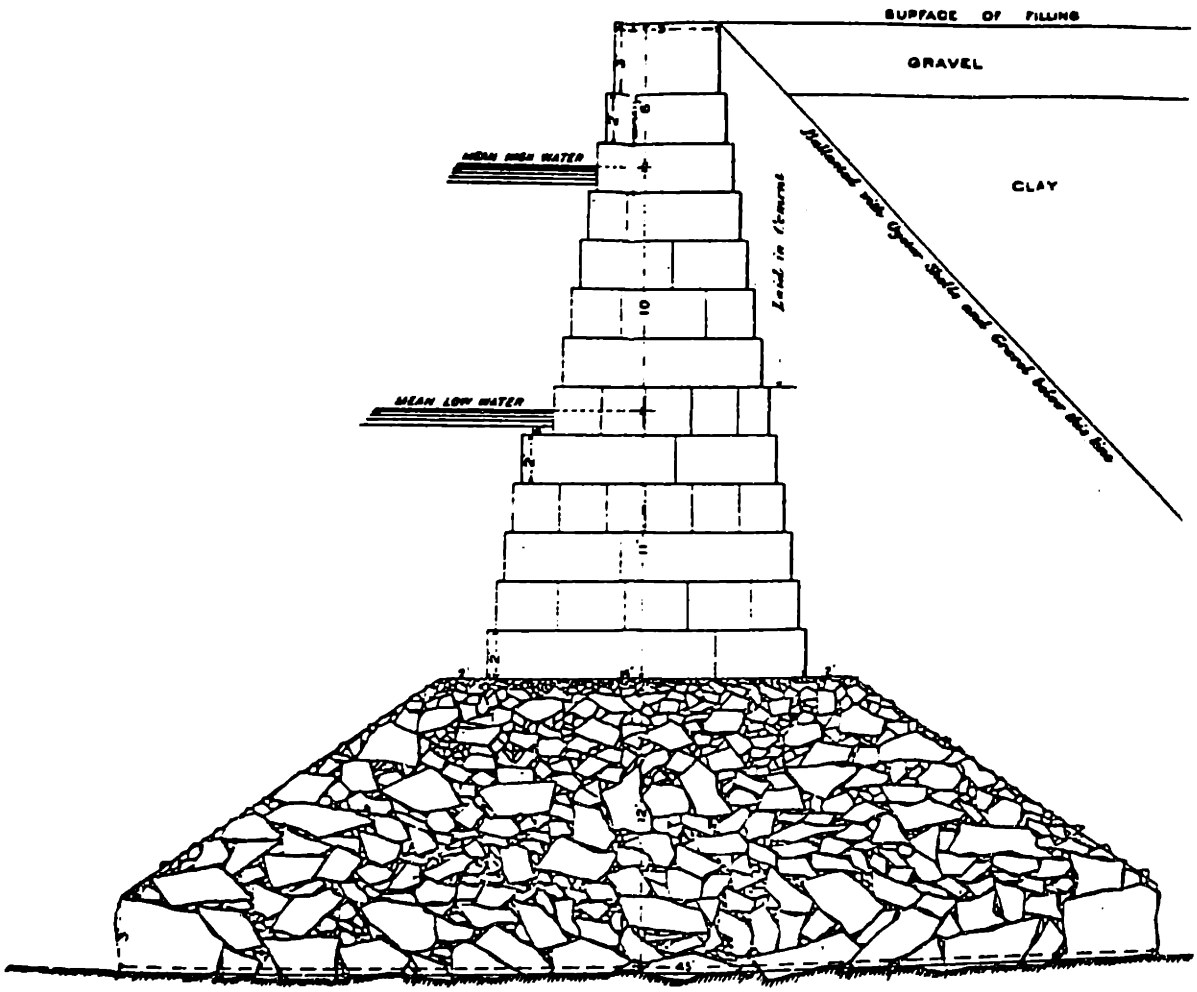


Figure 8-7: Typical Cross-section of Heavy Seawall 'B'

(Harbor Commissioners of the State of Massachusetts, 1878)

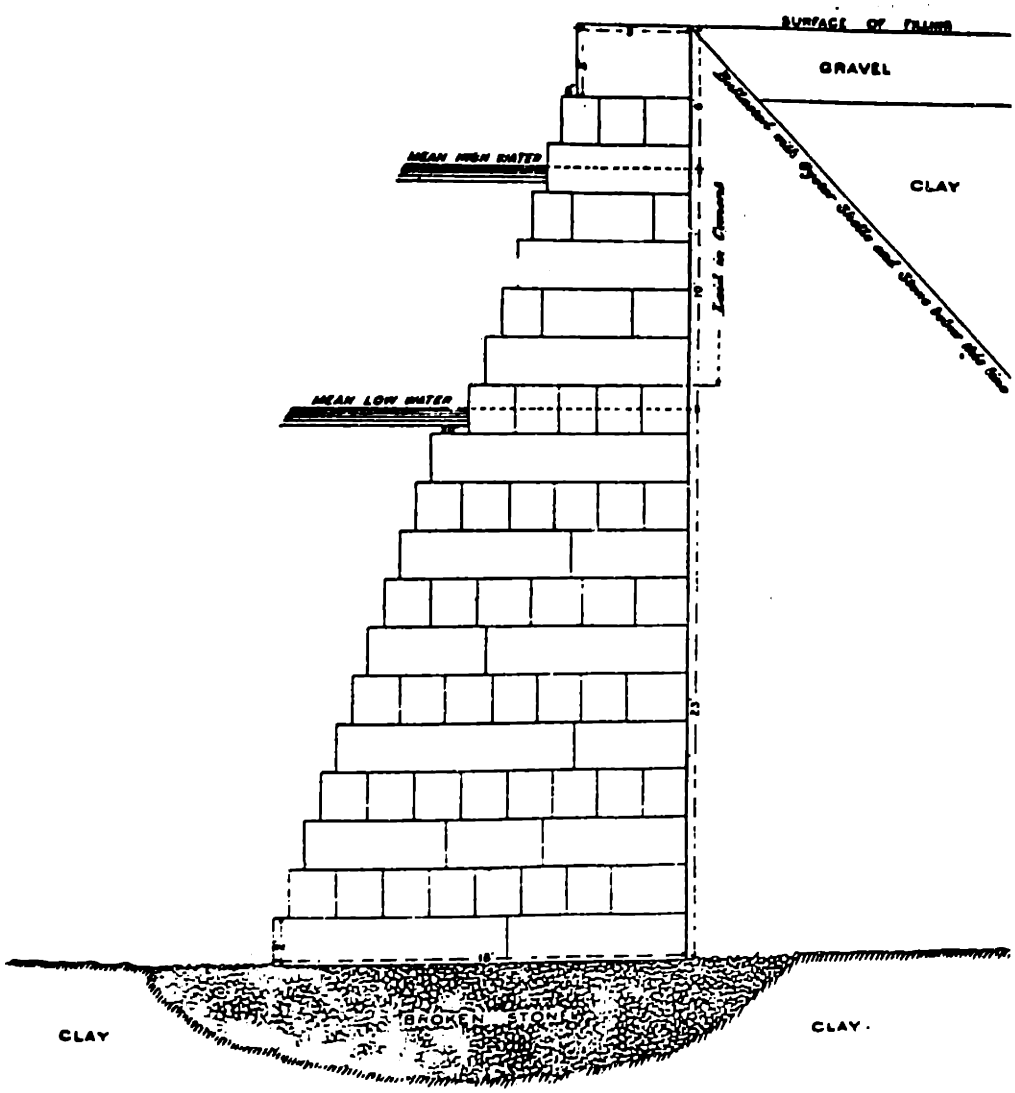


Figure 8-8: Typical Cross-section of Heavy Seawall 'C'

(Harbor Commissioners of the State of Massachusetts, 1878)

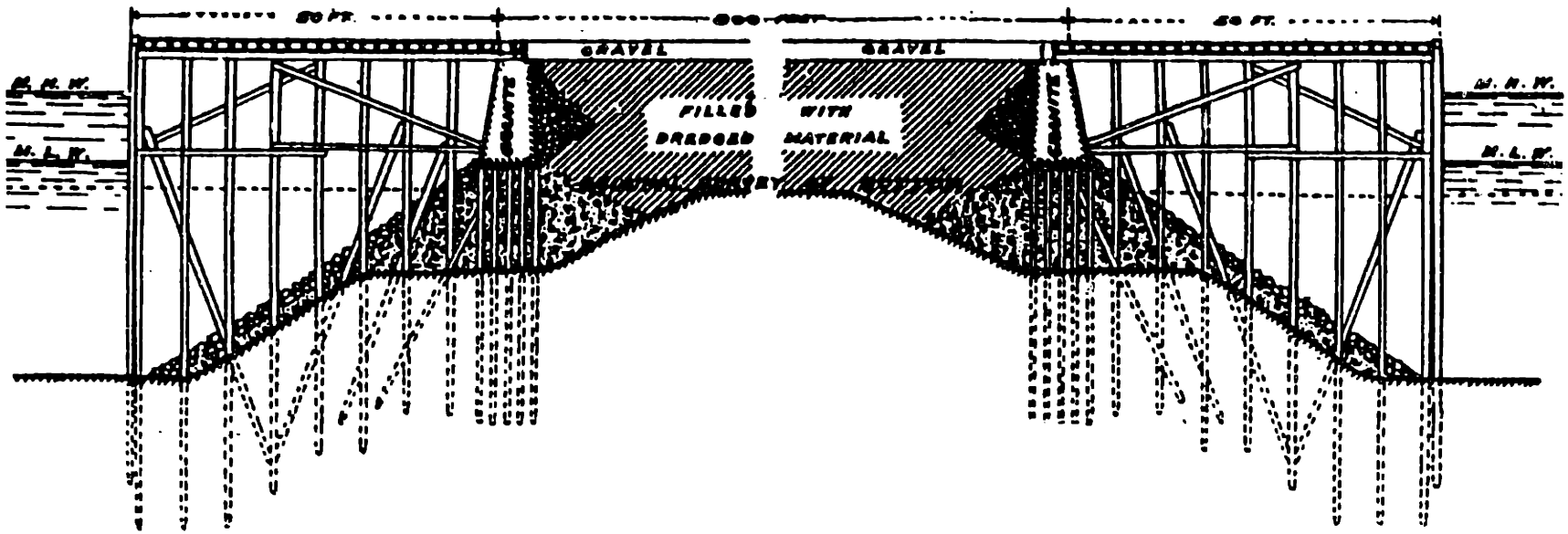


Figure 8-9: Typical Cross-section of Commonwealth Pier (Harbor and Land Commissioners, 1910)

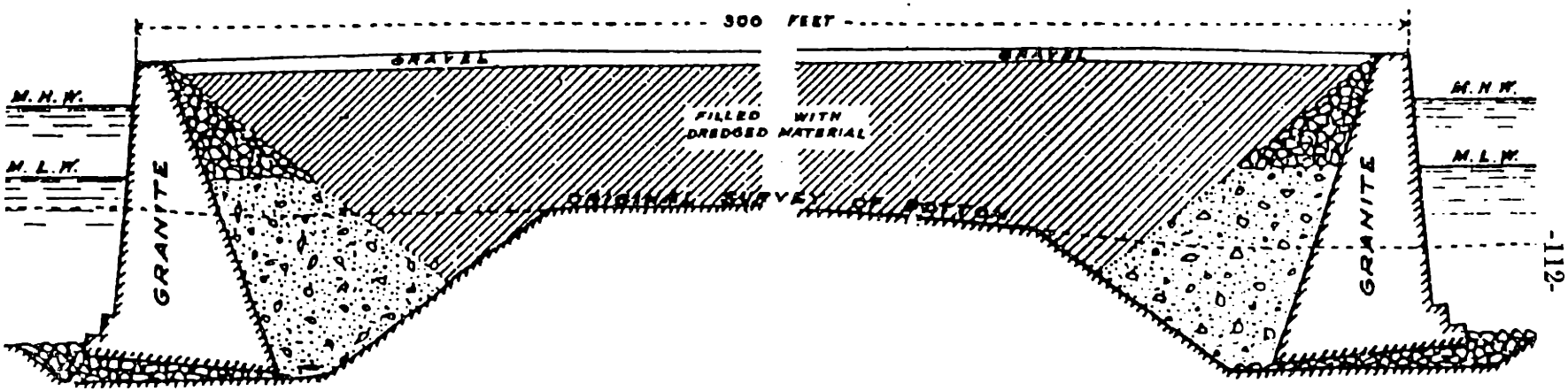


Figure 8-10: Typical Cross-section of Pier 6 (Harbor and Land Commissioners, 1910)

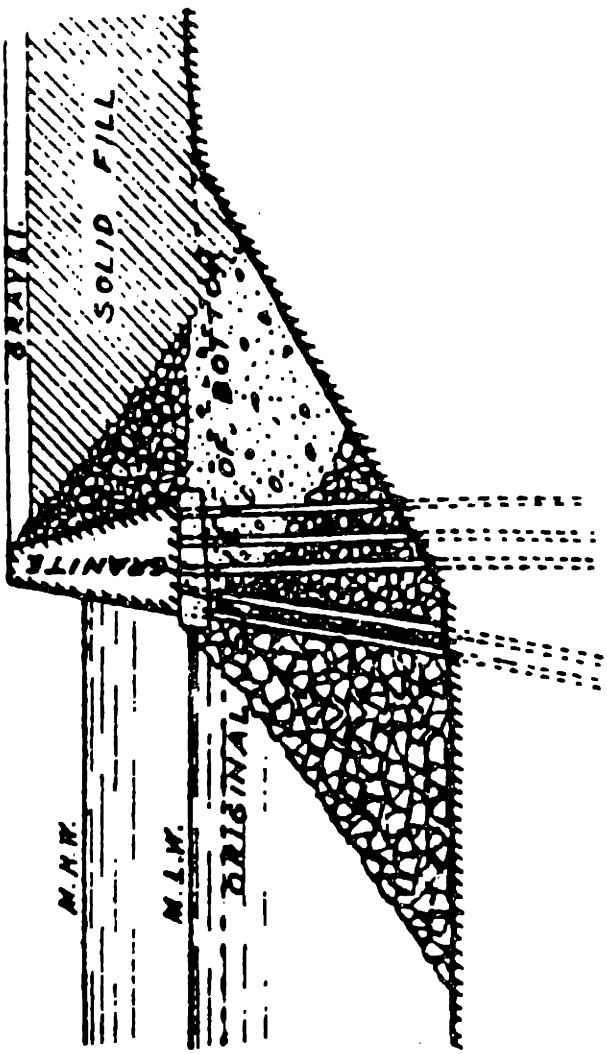


Figure 8-11: Typical Cross-section of Seawall 'F' (Harbor and Land Commissioners, 1910)

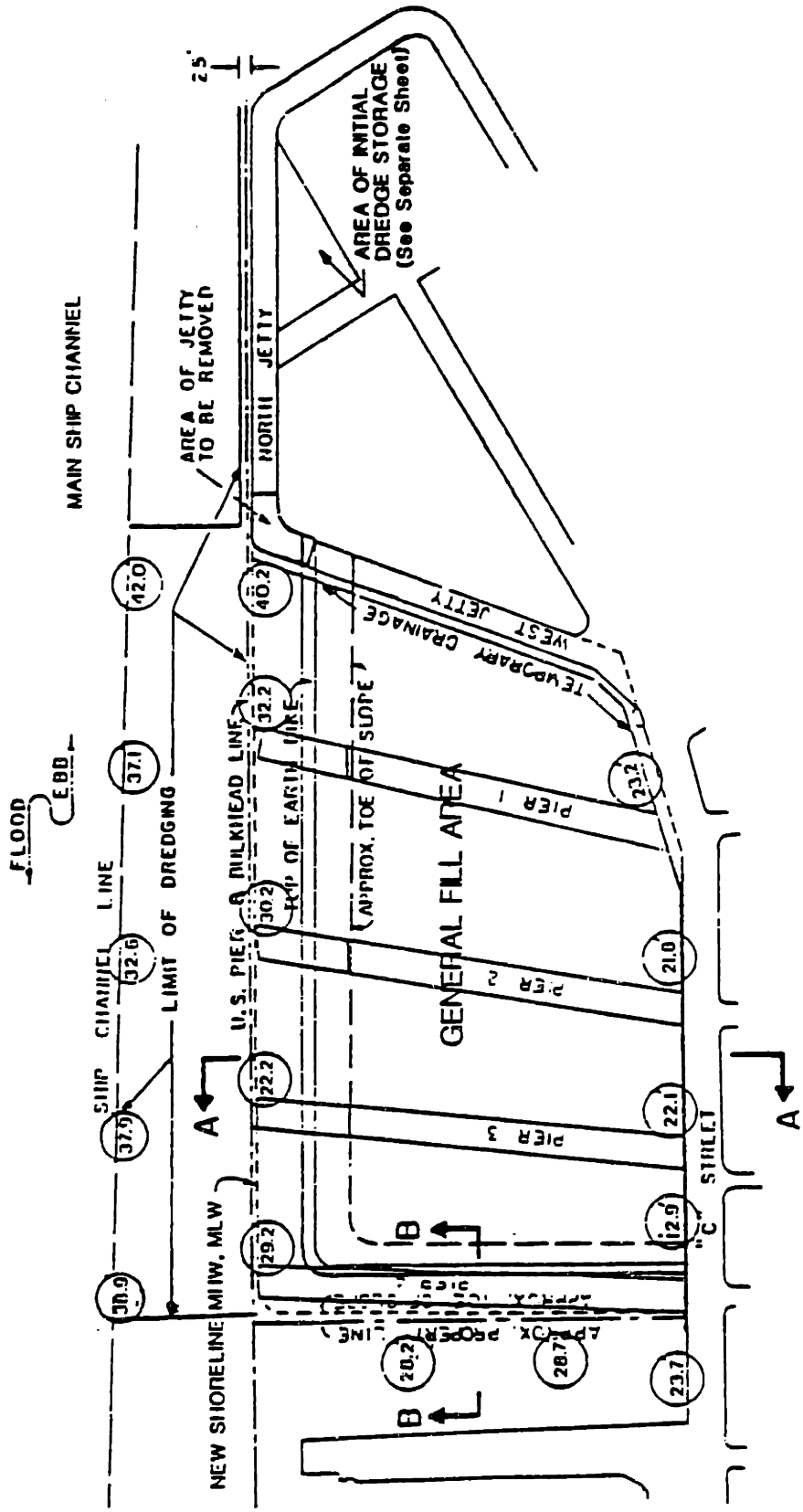


Figure 8-12: Site Plan of area 'SB12' (Cortell, Jason M., 1980)

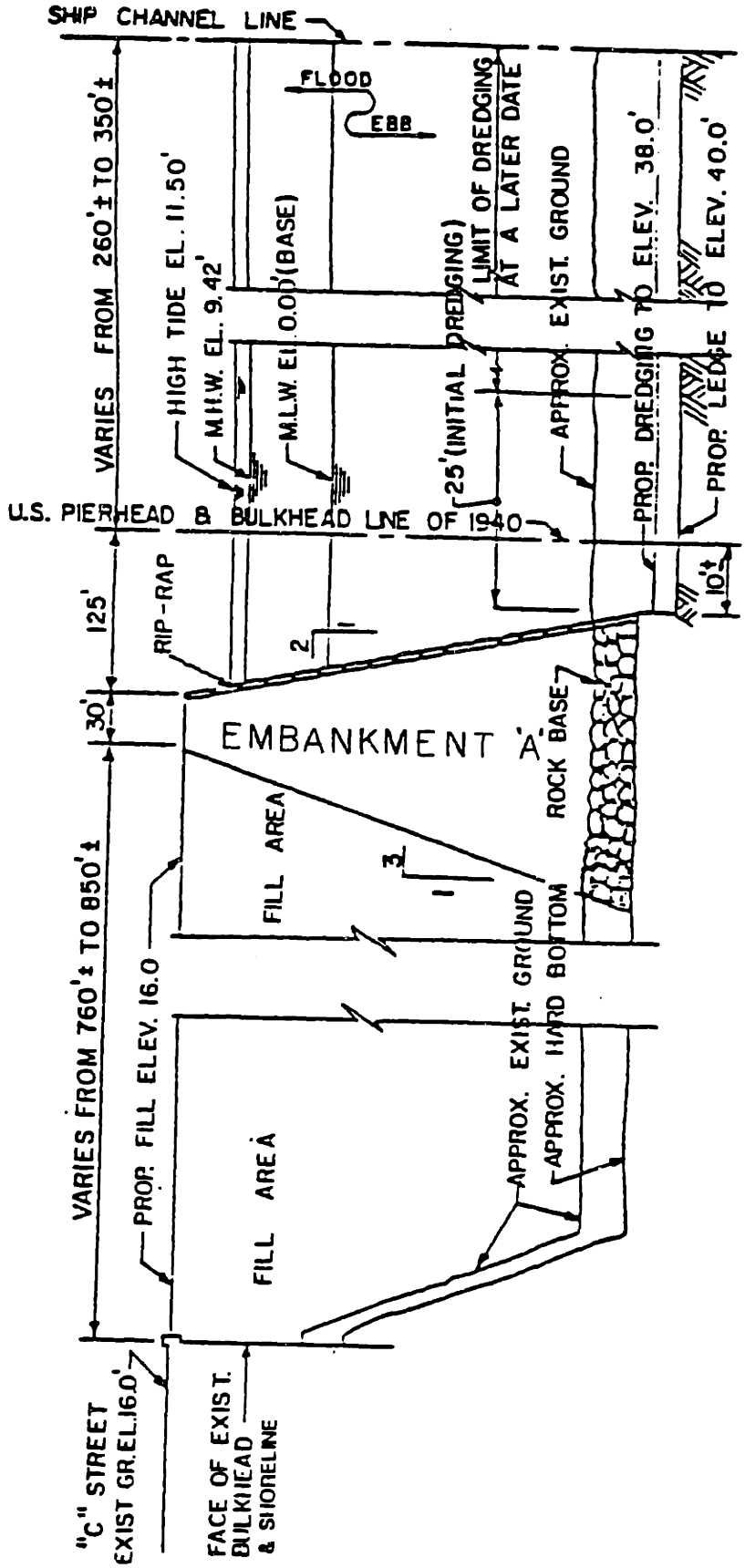


Figure 8-13: Typical Cross-section of Embankment 'A' (Cortell, Jason M., 1980)

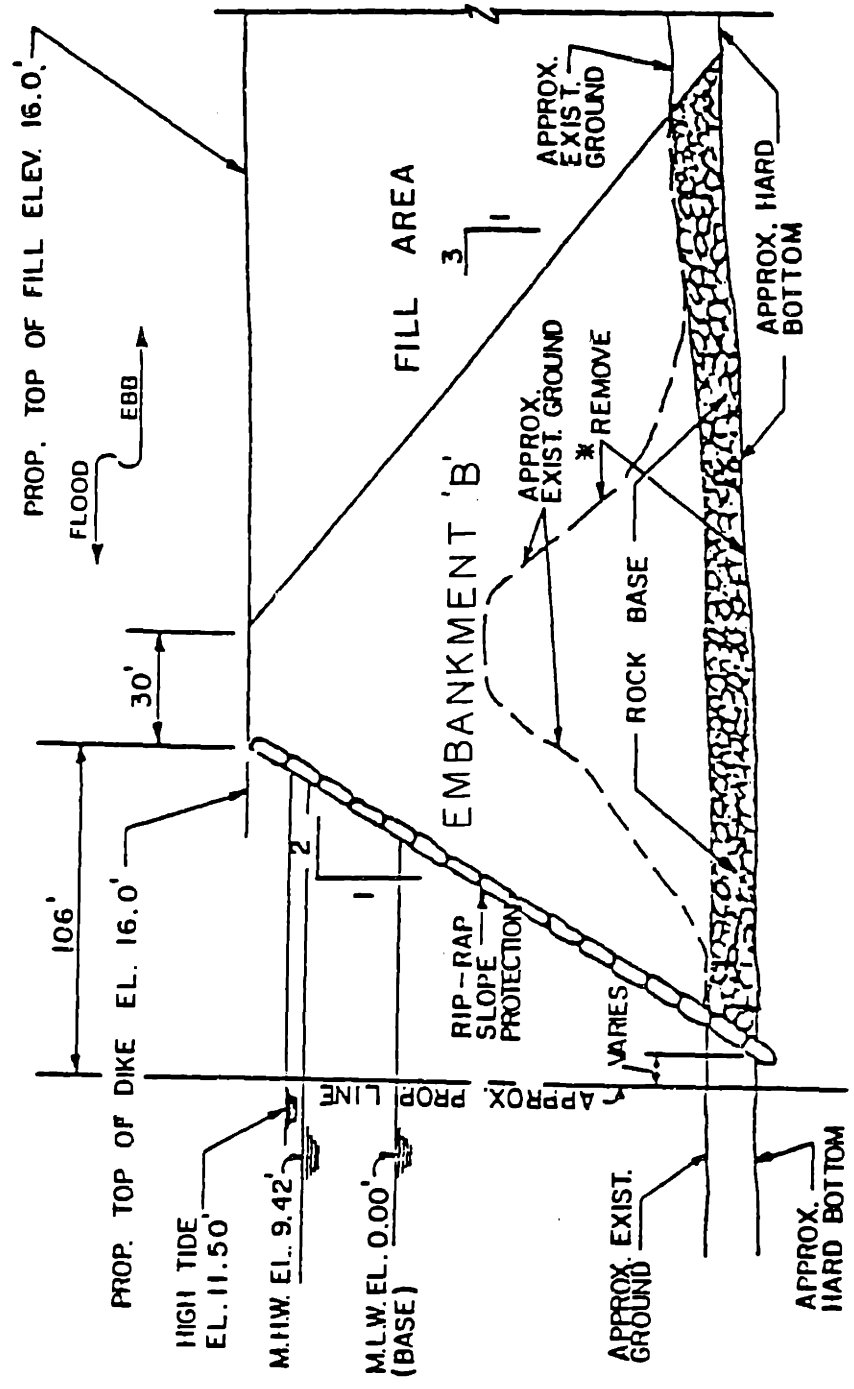
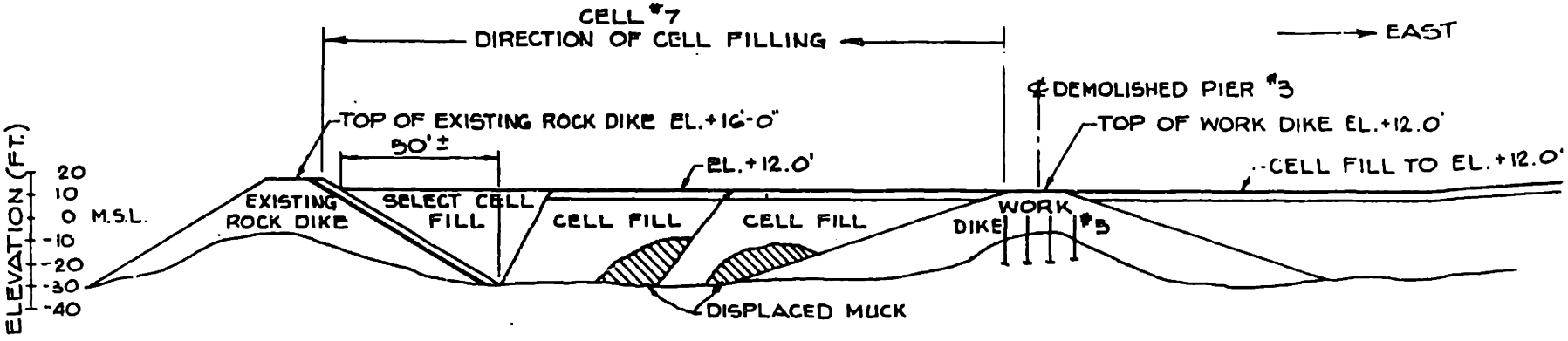


Figure 8-14: Typical Cross-section of Embankment 'B' (Cortell, Jason M., 1980)



SEQUENCE OF CELL FILLING (CELL #7)

1. PLACE CELL FILL UNIFORMLY (N-S & S-N) ACROSS CELL OR AS DIRECTED BY THE ENGINEER CONTINUOUSLY FILLING TOWARDS EXISTING ROCK DIKE, MAINTAINING A SLOPE AS STEEP AS POSSIBLE TO INSURE DISPLACEMENT OF ALL MUCK. STOP PLACING CELL FILL AS SHOWN ABOVE. AND PLACE SELECT CELL FILL WITHIN THE LIMITS SHOWN.

2. DREDGE DISPLACED MUCK DURING CELL FILLING AS DIRECTED. DISPLACED MUCK SHALL BE SPREAD, DRIED AND MIXED WITH CELL FILL FROM EL.+10.0 TO +12.0.

3. REMOVE ALL DISPLACED MUCK FROME SLOPE OF ROCK DIKE BEFORE PLACING SELECT CELL FILL.

Figure 8-15: Typical Cross-section during Filling Process (Cortell, Jason M., 1980)

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Chapter 9

South Cove and South Bay

9.1 Introduction

South Cove was located in the southern part of original Boston peninsula, and South Bay was an extension of the cove. Map 9.2 shows South Cove and South Bay with the original shorelines and water channels. The cove and bay covered a total area of about three hundred acres. Filling began in South Cove in the early eighteenth century. The filling history lasted for about one and a half centuries. Today, Fort Point Channel is the only unreclaimed part of the area. Filling materials such as gravel from Fort Hill, mud from South Bay, city ashes and refuses, etc., were used.

9.2 South Cove

Landfill began at the neck between the Boston peninsula and the mainland. In 1804, filling for Harrison Avenue and adjacent areas (area 'SC1' in Map 9.4) was started. The avenue is running parallel to Washington Street, the Boston neck. This piece of landfill had a surface area of about nine acres. Gravel from Fort Hill was used as filling material. The gravel was dug by hand, then transported by carts and dumped onto the site. After one year, the avenue was laid out from the original shoreline to South Boston Bridge (see Map 9.4). Wharves and docks were built along the avenue and the shore of South Cove. The wharves were usually supported

on timber piles driven into the mud. The 1814 wharfline is shown in Map 9.2. The area south of 'SC1' (area 'SC2' in Map 9.4) was filled in the 1820's. Gravel from Fort Hill was used again.

During the period 1833 to 1839, the main portion of South Cove (area 'SC3' in Map 9.4) was filled. It had a surface area of about fifty-five acres. Lincoln Street, part of Albany Street and today's Chinatown were created. Two types of fill materials were used. Mud dredged from the South Bay and today's Fort Point Channel was used. Gravel was used as surface material placed on top of the mud fill. The gravel was brought from pits in Roxbury and Dorchester by boat, and from Brighton by rail. Another generation of wharves was constructed along the shore of area 'SC3'; the 1850 wharfline is shown in Map 9.3.

9.3 Western Portion of South Bay

For many years, South Bay was a receiving basin for sewage and other wastes. Storm water was discharged with the sewage from combined sewers. The bed of the bay originally was mud and silt, which became septic from the discharge of diluted sanitary sewage, decaying vegetable matter and fuel oil.

Between 1844 and 1872, the western portion of South Bay (areas 'SBY1' and 'SBY2' in Map 9.4) was filled and Albany Street was laid out. Filling began in the southern tip and progressively continued northward. A wall (seawall 'A' in Map 9.4) was built and filling material was placed behind it. Construction of the wall and the filling process are described in the following paragraphs.

The wall was supported on a pile foundation. A trench along the location of the wall was first excavated to a width of sixty feet and a depth of twelve feet below mean low water. At locations where the surface of clay was above this level, excavation was done to the clay surface only. Before filling the trench, spruce piles of ten inch diameter were driven into the clay. The piles were driven in rows of six across the wall and with a longitudinal spacing of two feet along the wall. The piles were usually driven eight feet into the clay but if the clay was soft, they were driven further down. All the piles were cut off at mean low water. The trench was then filled with gravel to mean low water under and behind the wall and to three feet below mean low water in front of the wall. The wall was then built on the pile and gravel fill foundation. It was made of granite stones and had a length of over three thousand feet. The wall was fourteen feet high, eleven feet wide at base and three feet wide on the top. Rock and gravel ballast with ten feet wide at base and two feet wide on the top was placed behind the wall.

In the 1840's and 1850's, 'SBY1' was filled and several docks were constructed along the wall. Mud excavated from the adjoining area of South Bay, Fort Point Channel, the entrance to Roxbury Canal and the trench under the wall was used as fill material. Two feet of gravel was placed on top of the mud. The gravel was obtained from a gravel bank near Willow Court at Dorchester and was transported by boat to the destination.

During the period of 1866 to 1872, area 'SBY2' with a surface area of about twenty acres was filled. Gravel was excavated from Fort Hill by steam shovels, then

transported by rail and unloaded onto this area.

9.4 Southern and Eastern Portions of South Bay

In the early 1850's, the New York and New England Railroad embankment (see Map 9.3) was built across the South Bay. The railroad tracks were supported on a solid fill embankment (harbor and Land Commissioners,1891) but the source of filling material is not mentioned in the report. It is very likely that the solid fill is gravel. In the 1870's, a road embankment named 'Swell Street' (see Map 9.3), today's Southampton Street, was built across the southerly part of South Bay perpendicular to the New York and New England Railroad. Since then, the eastern and southern parts of South Bay were cut off by the railroad and the road embankment and became useless for navigation.

From 1892 to 1898, the southern portion of South Bay (area 'SBY3' in Map 9.4) was reclaimed. This land had a surface area of about forty-three acres. Filling material, mainly mud, was taken from the remaining portion of South Bay bounded by the harbor line. Five docks were constructed along the north side of the area (see Map 9.4).

The whole piece of land along the eastern side of South Bay (area 'SBY4' in Map 9.4) was filled with ashes collected from the city and mud obtained from excavations in the bay. During the 1880's and 1890's, a considerable amount of ashes and house dirt were dumped along Dorchester Avenue, i.e. the eastern part of 'SBY4'. Filling was desultory; ashes and dirt were carried by and dumped from

carts. In 1898 and 1899, a channel (see Map 9.3) was excavated after the construction of the five docks along 'SBY3'. The channel followed the western and southern sides of South Bay and was about thirty-seven hundred feet long and one hundred and ten feet wide. The average original bed elevation was about six feet below mean low water and it was excavated to a depth of twelve feet below mean low water, thus, there was an average cut of about six feet. The total amount of excavation was one hundred fourteen thousand cubic yards. In 1902 and 1903, the channel at the mouth of Roxbury Canal was enlarged into a triangular basin (see Map 9.3). Over one hundred fifty thousand cubic yards were excavated. In 1921, the entire channel was widened to one hundred sixty feet. During the 1900's and 1910's, frequent excavations were made in the bay to remove the nuisance of exposed flats at low tides. Most of the material obtained from such excavation was mud and silt, and the material was used in filling 'SBY4'. A stream, Dorchester Brook, remained between 'SBY3' and 'SBY4' (see Map 9.4).

NOTE: (i) 'SBY4' is shown as a filled land in the map by Crosby, 1915. But part of 'SBY4' is shown as unfilled in a later map by Sampson,1927.

(ii)An area marked 'C', north of area 'SBY4' (see Map 9.4), was filled in between 1850 and 1864. Wharves were built (see Map 9.3) before the land was reclaimed. No information could be obtained on how it was filled. It is believed that ashes and dirt were used as filling material as was the case for 'SBY4'.

9.5 Remaining Portion of South Bay

This area includes Roxbury Canal, Dorchester Brook and the northern portion of South Bay. In the late 1910's and early 1920's, the New York, New Haven and Hartford Railroad was filling its own land in South Bay (area 'SBY5' in Map 9.4). Ashes and refuses were collected from the city and dumped into the area. Previously excavated parts of South Bay might lie within this area thus complicating the subsoil conditions.

Bridges were built across Fort Point Channel and South Bay. As ships were built taller and taller, these bridges encumbered the movement of the vessels into the bay. By the 1930's, the bay and channel had become useless for shipping and trading purpose. The docks along the west side of the channel disappeared during the decline of South Bay. As the population increased and the bay decreased in size, the sewage concentration had reached a dangerous level. So, it was proposed that the Roxbury Canal, Dorchester Brook and the remaining South Bay should be filled.

In 1957 and 1958, the John F. Fitzgerald (Southeast) Expressway was constructed and an earth embankment roadway (see Map 9.4) was built to replace Dover Street bridge (see Map 9.3). Considerable organic silt and other miscellaneous fill from the construction of the expressway was deposited in Roxbury Canal and South Bay. Two culverts were built under the expressway and embankment to allow water flow.

In the late 1950's and early 1960's, the remaining part of South Bay (area

'SBY6' in Map 9.4) was filled. Before filling took place, concrete conduits were constructed along Roxbury Canal and Dorchester Brook which merged at South Bay (see Map 9.4). The conduits are for collection of both sewage and storm runoff which were divided into three sections supported on different foundations (Fig. 9-1):

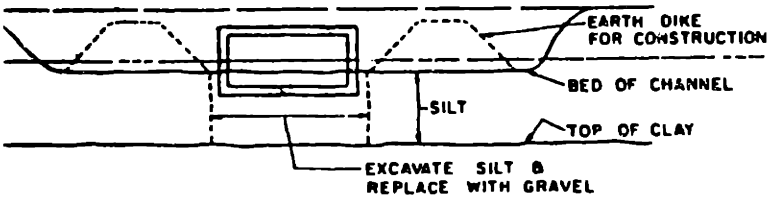
Section 1: The upper portion of the conduit was constructed on a gravel embankment placed after excavation of organic silt, earth dikes were constructed to facilitate dewatering so that construction could proceed in the dry.

Section 2: The next section ended at the existing expressway conduit. This section was supported on timber friction piles driven through the organic silt into the clay stratum. Earth dikes were also used for dewatering.

Section 3: The lower portion of the conduit was founded on gravel backfill placed after organic silt was excavated down to the clay, all construction took place within a double steel sheet pile cofferdam which remained in place as an integral part of the culvert.

Fig. 9-2 shows the profile for different sections of conduit.

'SBY6' was filled in the late 1950's and early 1960's. Filling material was from different construction projects in Boston which included the Prudential Center, the garage under the Boston Common, the Federal Center near Scollay Square and the Callahon Tunnel to East Boston. The material obtained was mainly till which consisted of sand and gravel.



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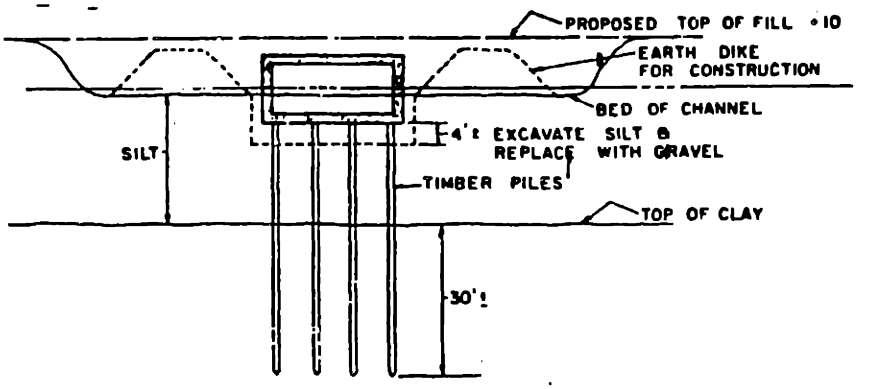

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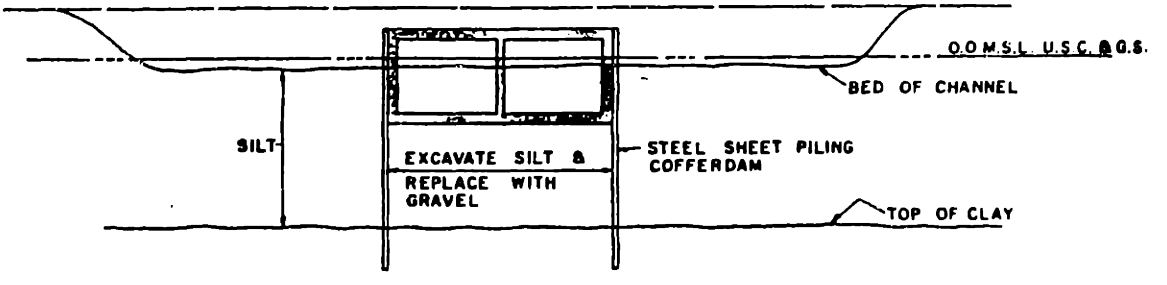

SECTION 3

Figure 9-1: Typical Cross-sections of Conduit

(Commonwealth of Massachusetts, 1959)

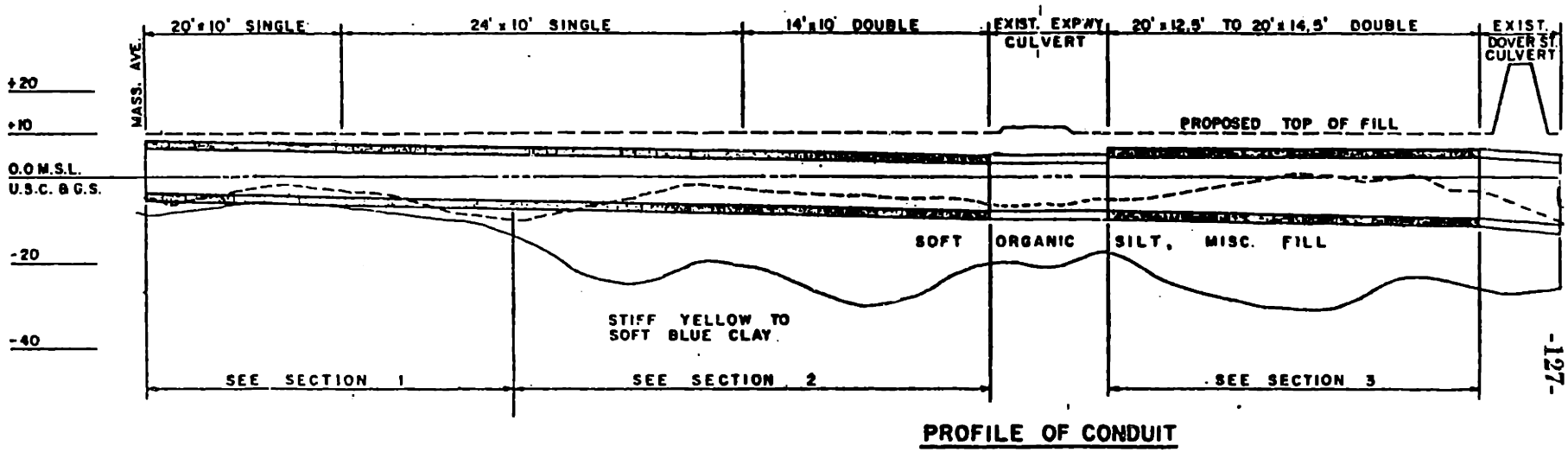

Figure 9-2: Profile of Conduit (Commonwealth of Massachusetts, 1959)

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Chapter 10

Conclusions

Details of the history and characteristics of Boston landfill were presented in this report. Specifically the types of filling material, the filling procedure and the time of filling were discussed. In general, granite seawalls, wooden bulkheads and/or earthdikes were built around a filled area, in order to protect the area from the tides and keep the filling material stable. Many types of filling materials were used, and each type of filling material was usually transported/handled in a specific way. Ashes and refuse was carried by carts. Material obtained by excavating hills or quarries was usually transported by rail. Material dredged below water was either excavated by clam-shell dredge, then loaded onto scows and carried to the final site or it removed by hydraulic dredge, which was introduced in the late nineteenth century, and pumped as slurry through pipes to its final location.

Many of the filled areas in this study are closely related to wharf construction. Early wharf construction in the eighteenth and nineteenth century took place in East Cove, South Cove and East Boston. Many of these wharves do not exist anymore, because of further filling or reclamation.

For each of the area studied, maps were drawn which show the original shoreline, topographical changes such as seawalls, road and railroad embankments. Each filled area is shaded differently and its filling procedure and material

characteristics are discussed in the text. The maps can be overlaid on each other.

Finally it is necessary to mention that for the following areas, no filling information was found:

(a) East Cove (Chapter 2) - the area southwest of 'EC1' and 'EC2' (see Map 2.4)

(b) Cambridge (Chapter 5) - areas 'A' and 'B' (see Map 5.3)

(c) Charlestown (Chapter 6) - area 'U' (see Map 6.4)

(d) South Boston (Chapter 8) - area 'A' (see Map 8.3)

(e) South Bay (Chapter 9) - area 'C' (see Map 9.4)

This study required substantial searching for old documents, reports and maps in libraries. Pieces of information were put together such that they are consistent. In some cases, judgement was required because of inconsistency between reports or maps, if this was necessary it is mentioned in the text.

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93
Old Ironsides
ITERCHANGE
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EXPRESSWAY
Beacon Hill
Sta
House
Lib
Cem
Customhouse
Post Office
Fire Sta
CHARLES
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BERKELEY
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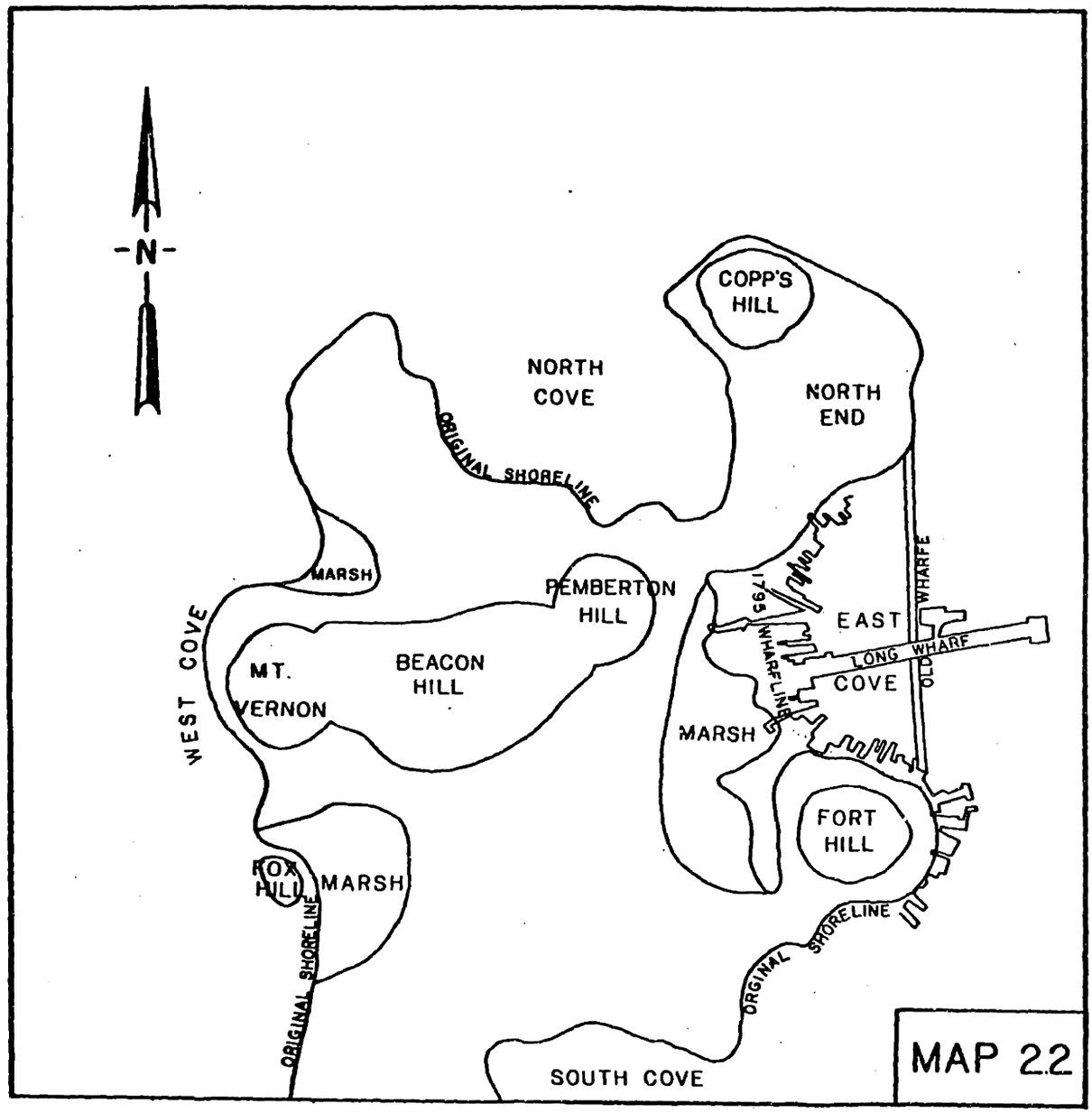
MAP 2.1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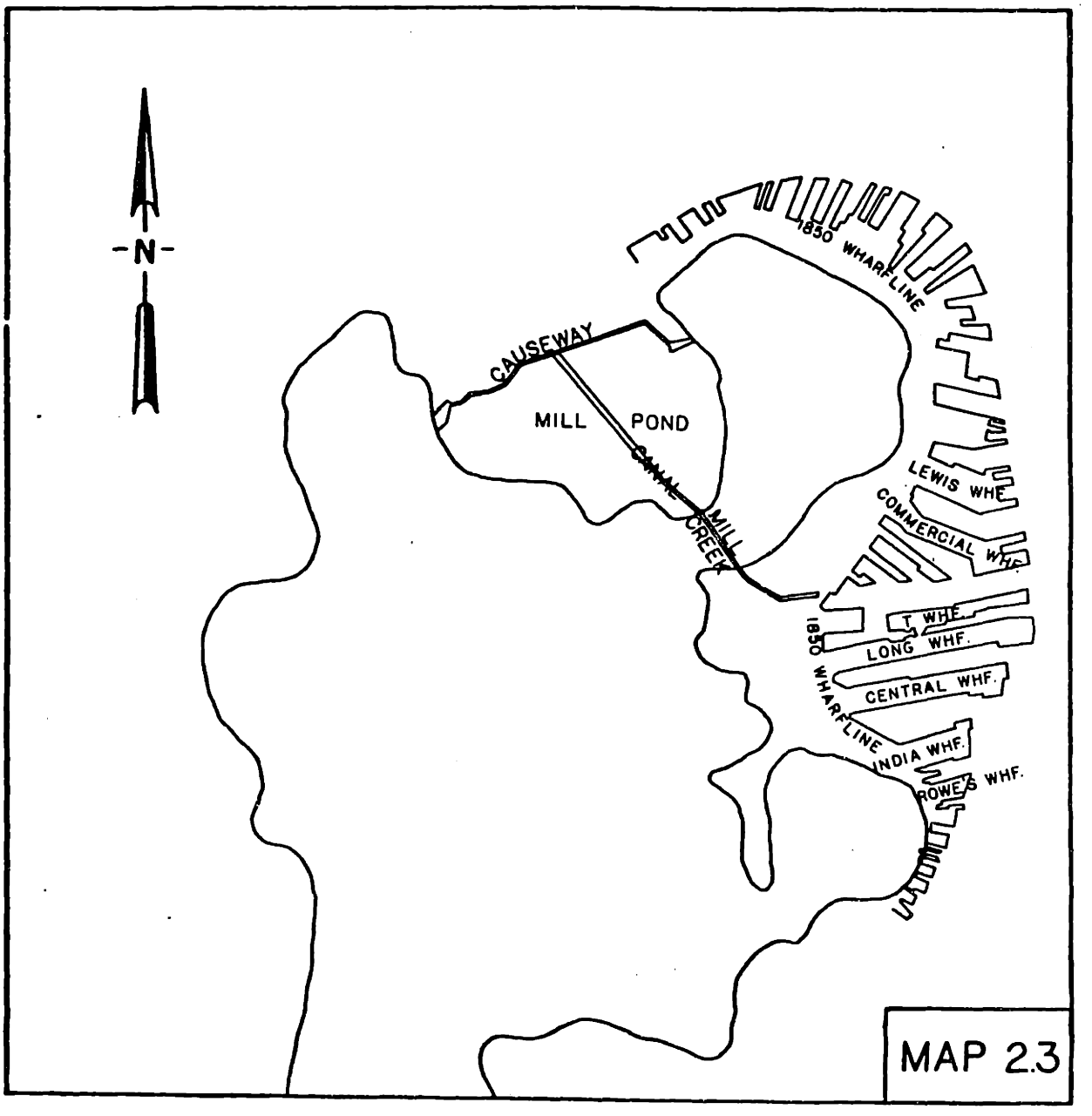
MAP 22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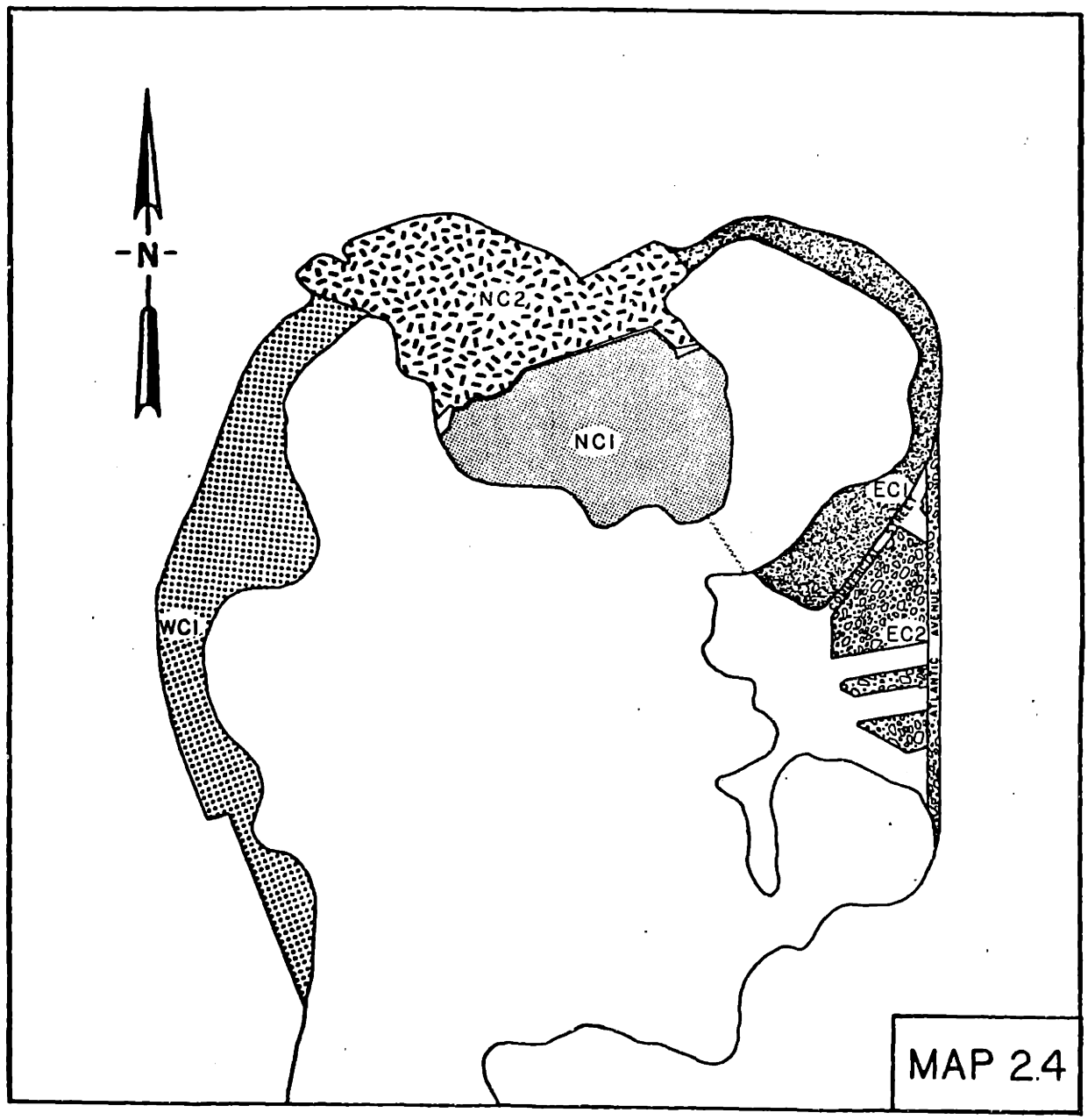
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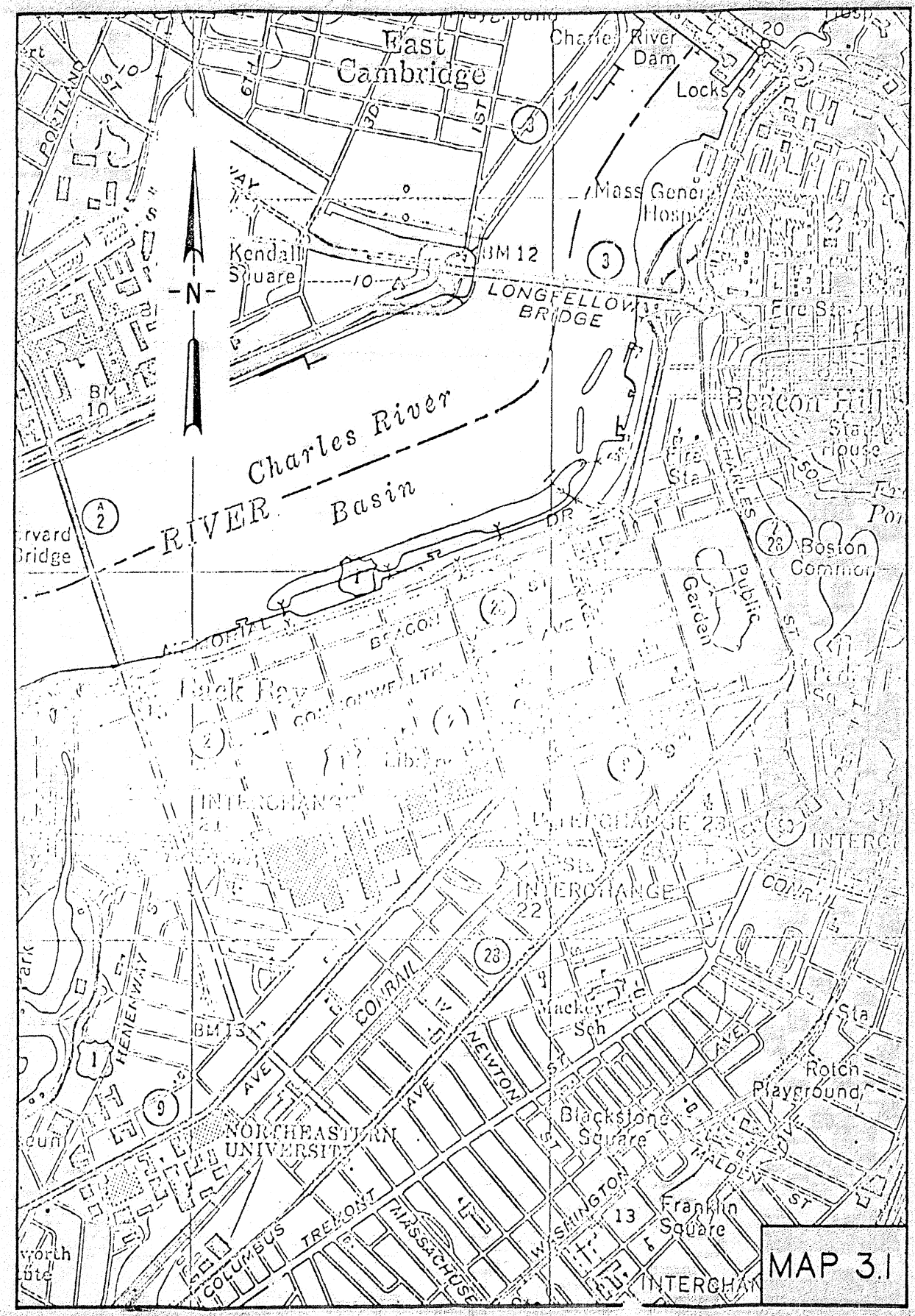
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Public Garden
Back Bay
INTERCHANGE 22
INTERCHANGE 23
CONRAIL
Mackey Sch
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Roach Playground
Blackstone Square
Franklin Square
NORTHEASTERN UNIVERSITY
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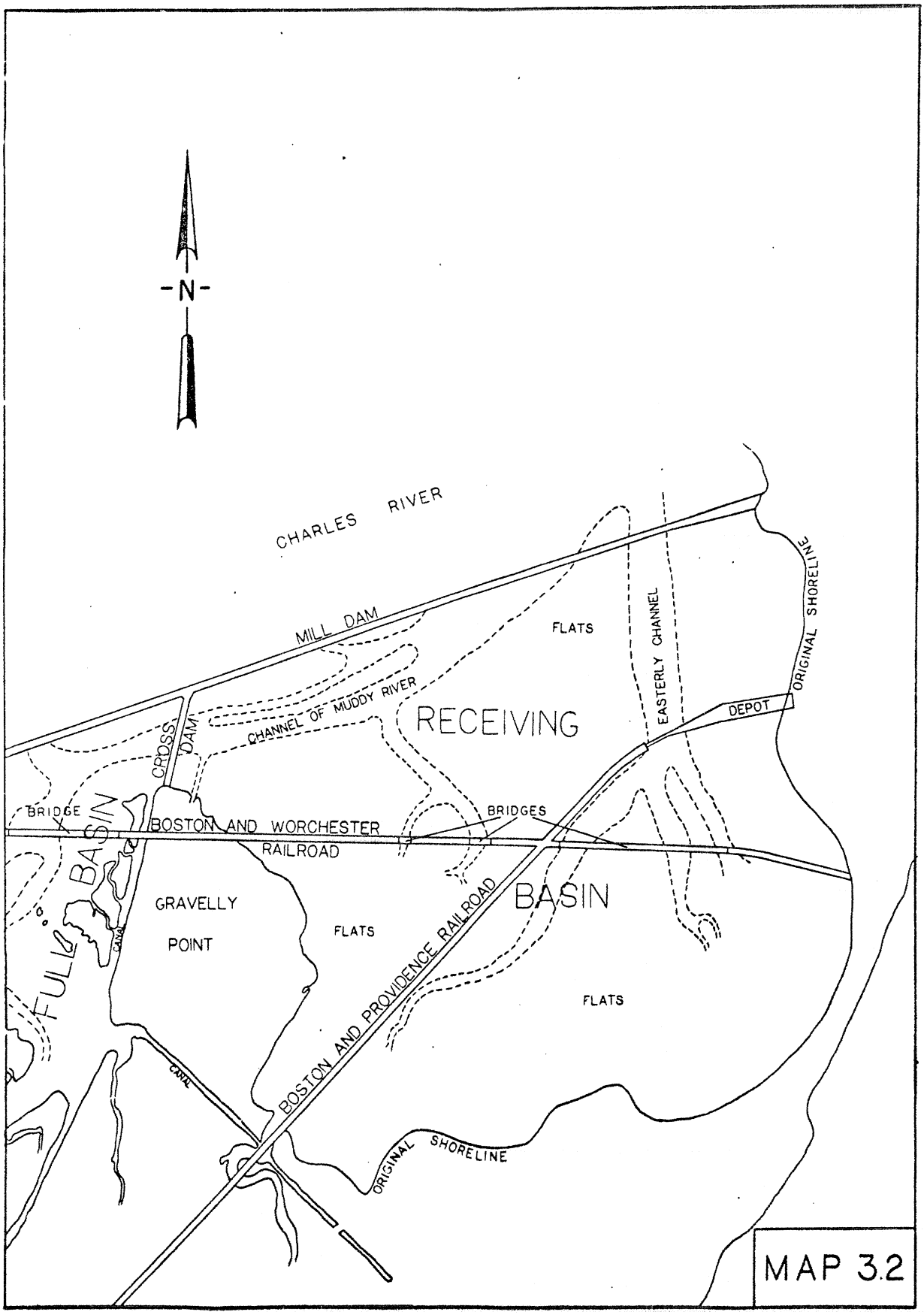
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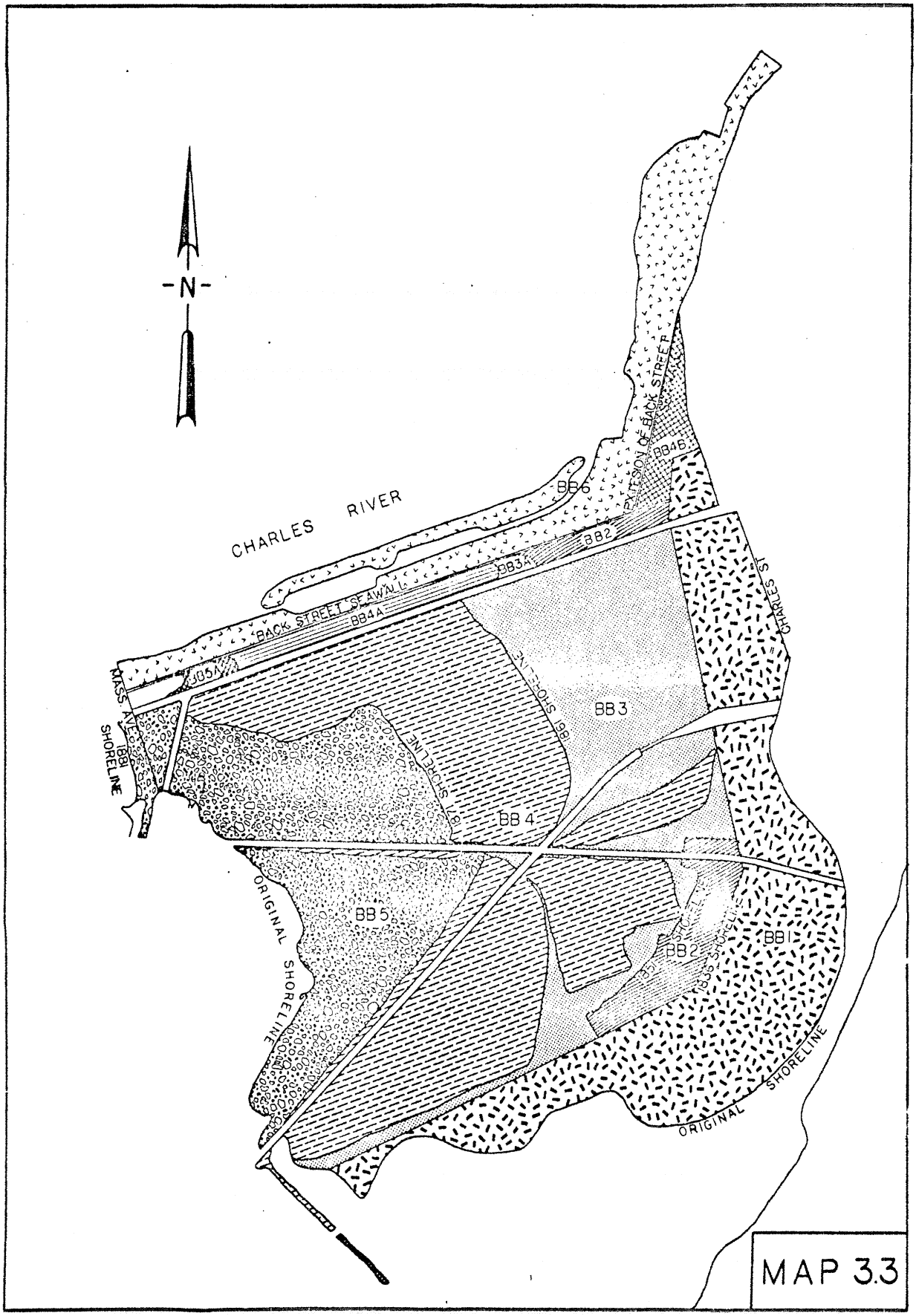
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MASS AVE.
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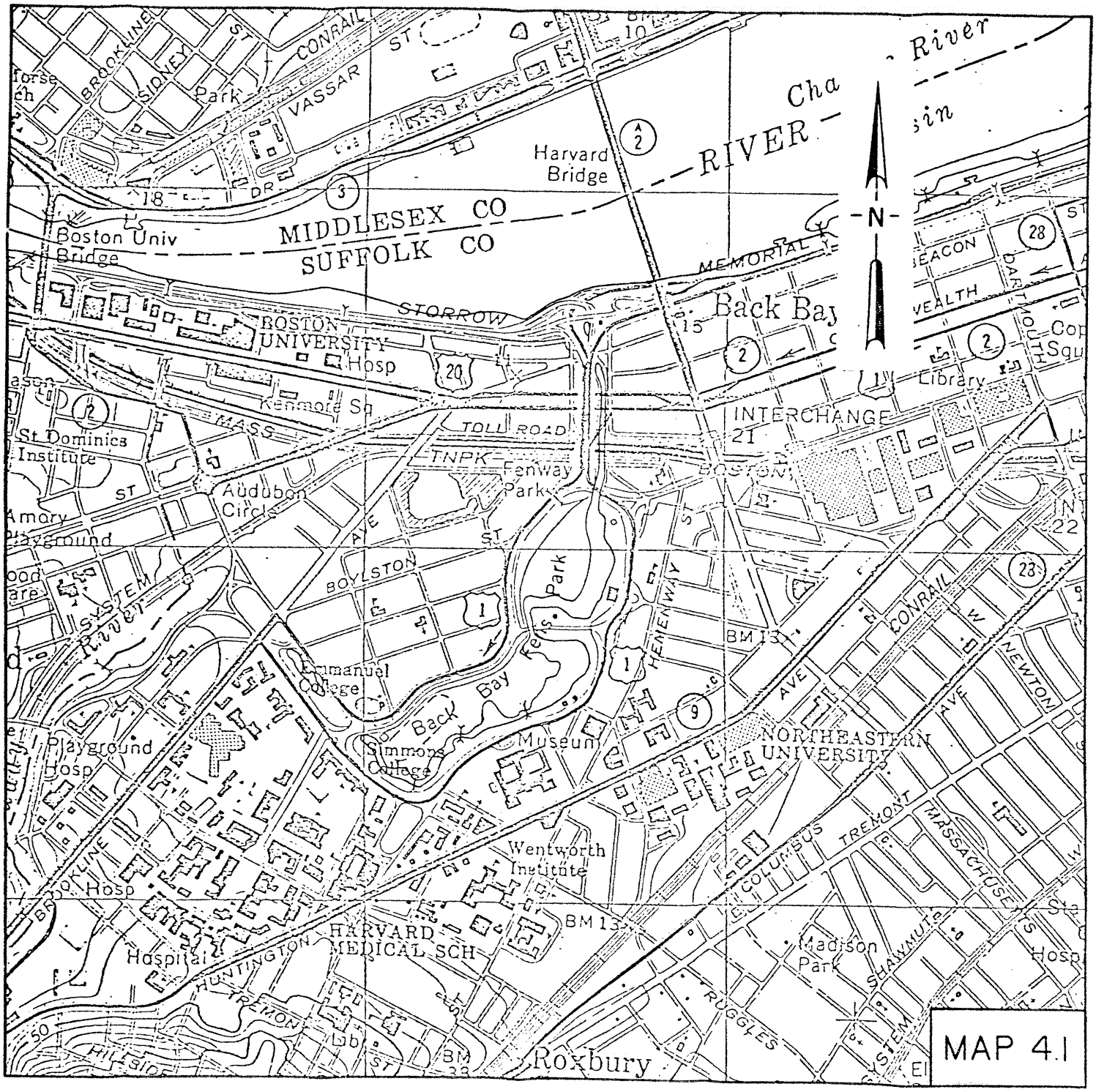
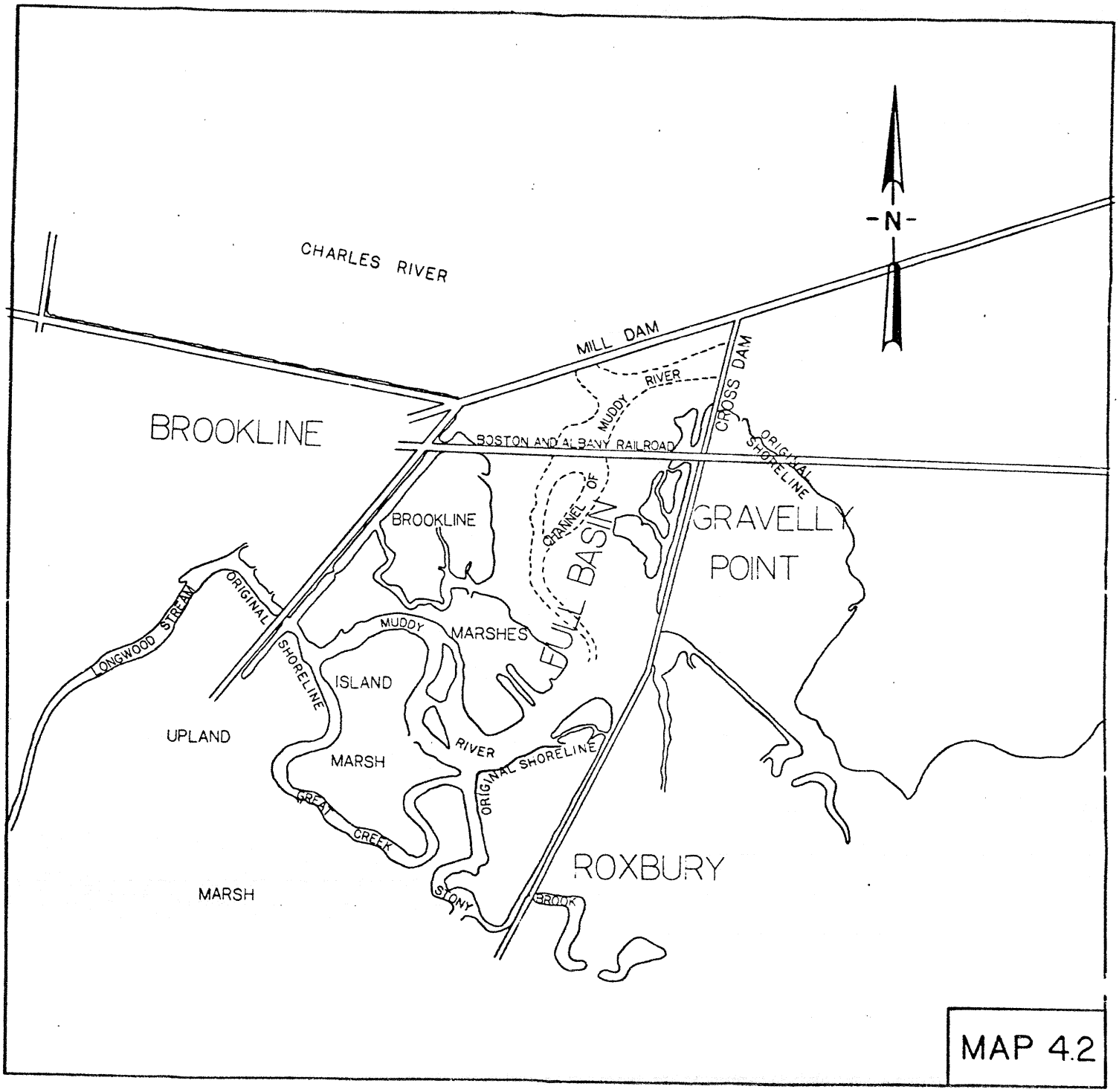
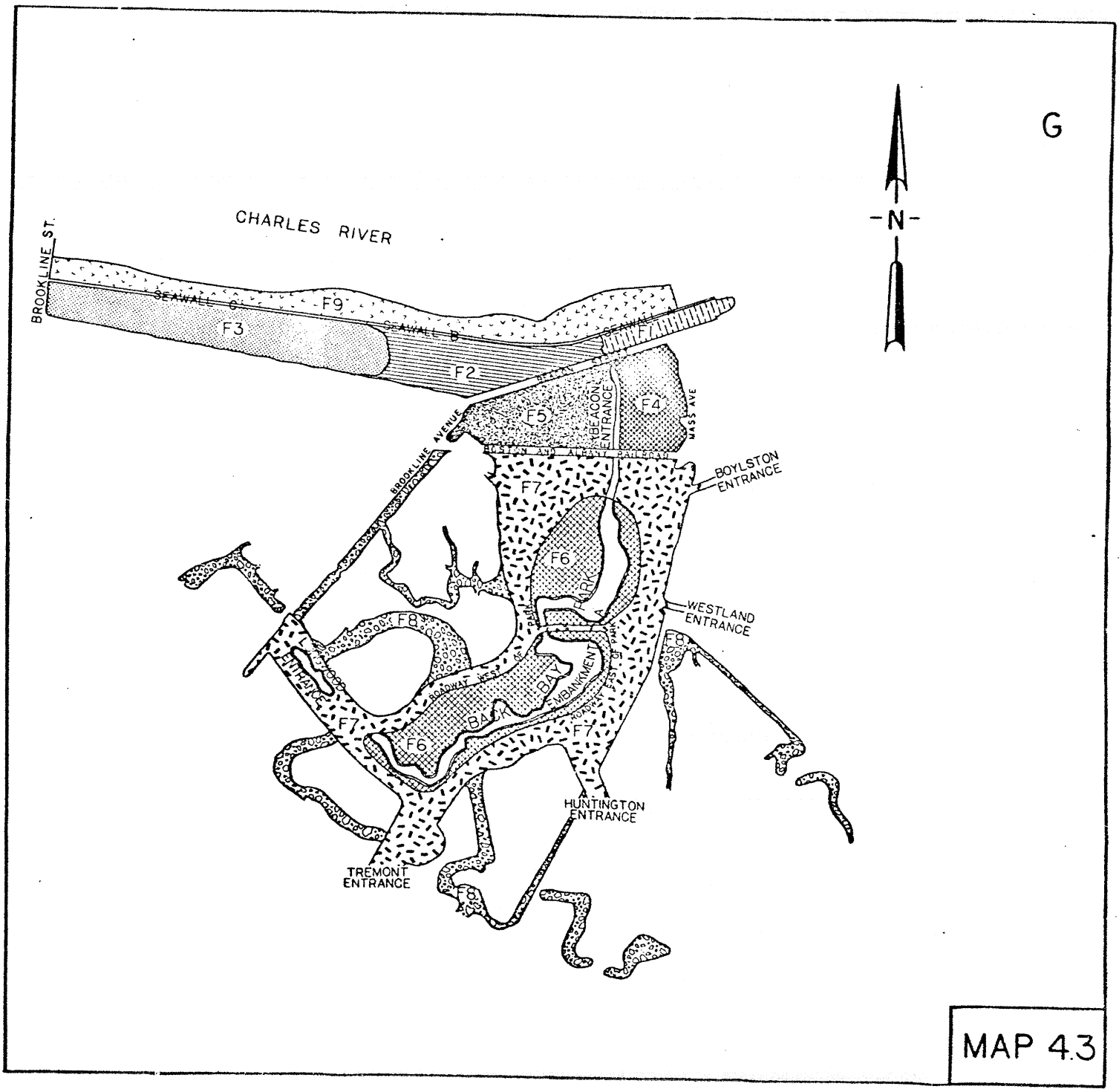
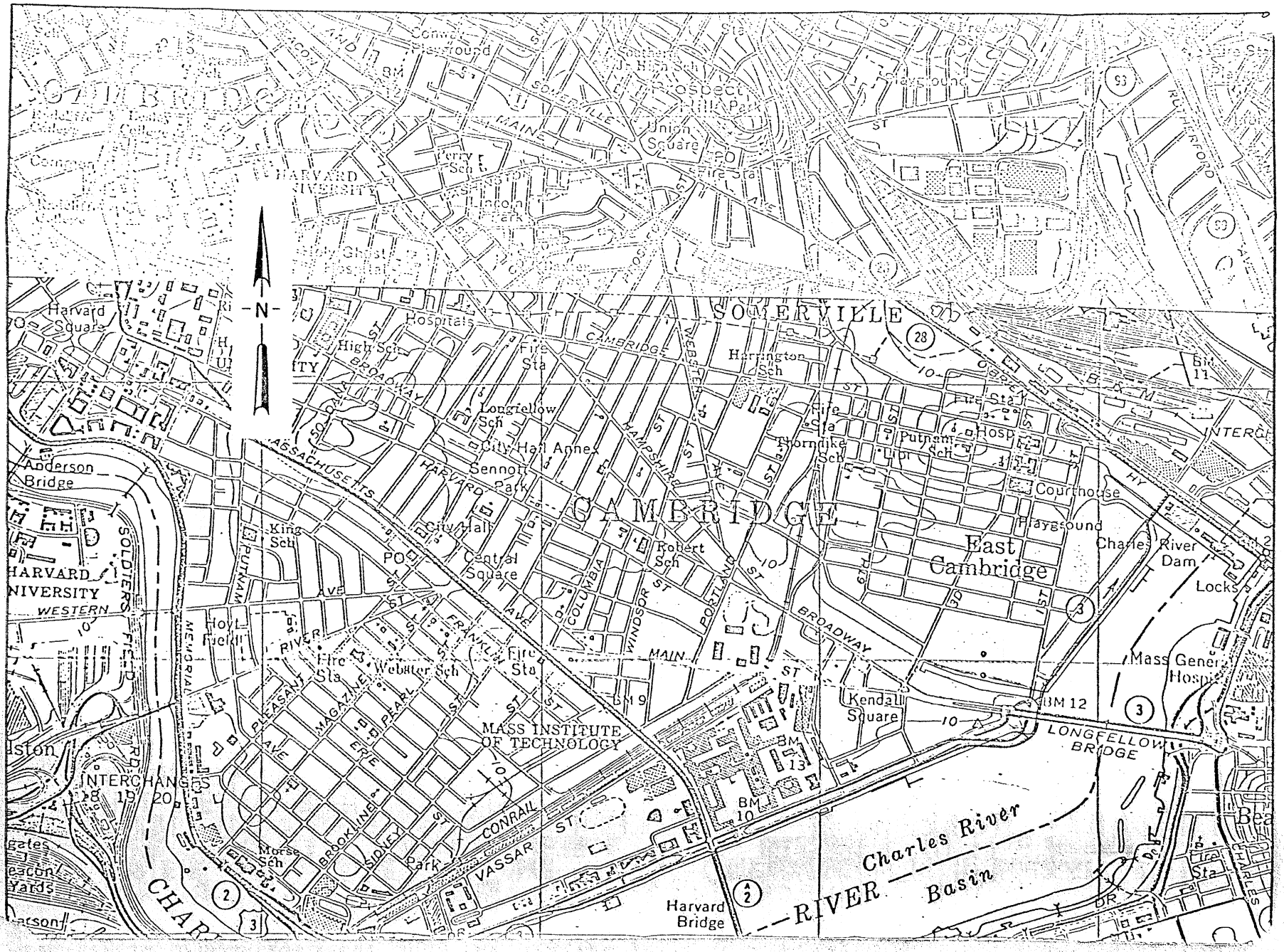
ORIGINAL SHORELINE
MAP 3.3


MIDDLESEX CO
SUFFOLK CO
RIVER
Harvard Bridge
Boston Univ Bridge
CONRAIL
VASSAR
BROOKLINE
SIDNEY
Park
ST
DR
MEMORIAL
STORROW
BOSTON UNIVERSITY Hosp
Kenmore Sq
MASS
TOLL ROAD
TNPK
INTERCHANGE 21
Back Bay
Library
St Dominics Institute
Audubon Circle
Fenway Park
Amory Playground
BOYLSTON
Back Bay Fens
HENRY WAY
Emmanuel College
Simmons College
Museum
NORTHEASTERN UNIVERSITY
CONRAIL
NEWTON
AVE
Playground
Hosp
Wentworth Institute
COLUMBUS
TREMONT
MASSACHUSETTS
BM 13
HARVARD MEDICAL SCH
Hospital
HUNTINGTON
Madison Park
SHAWMUT
RUGGLES
Roxbury
N
MAP 4.1

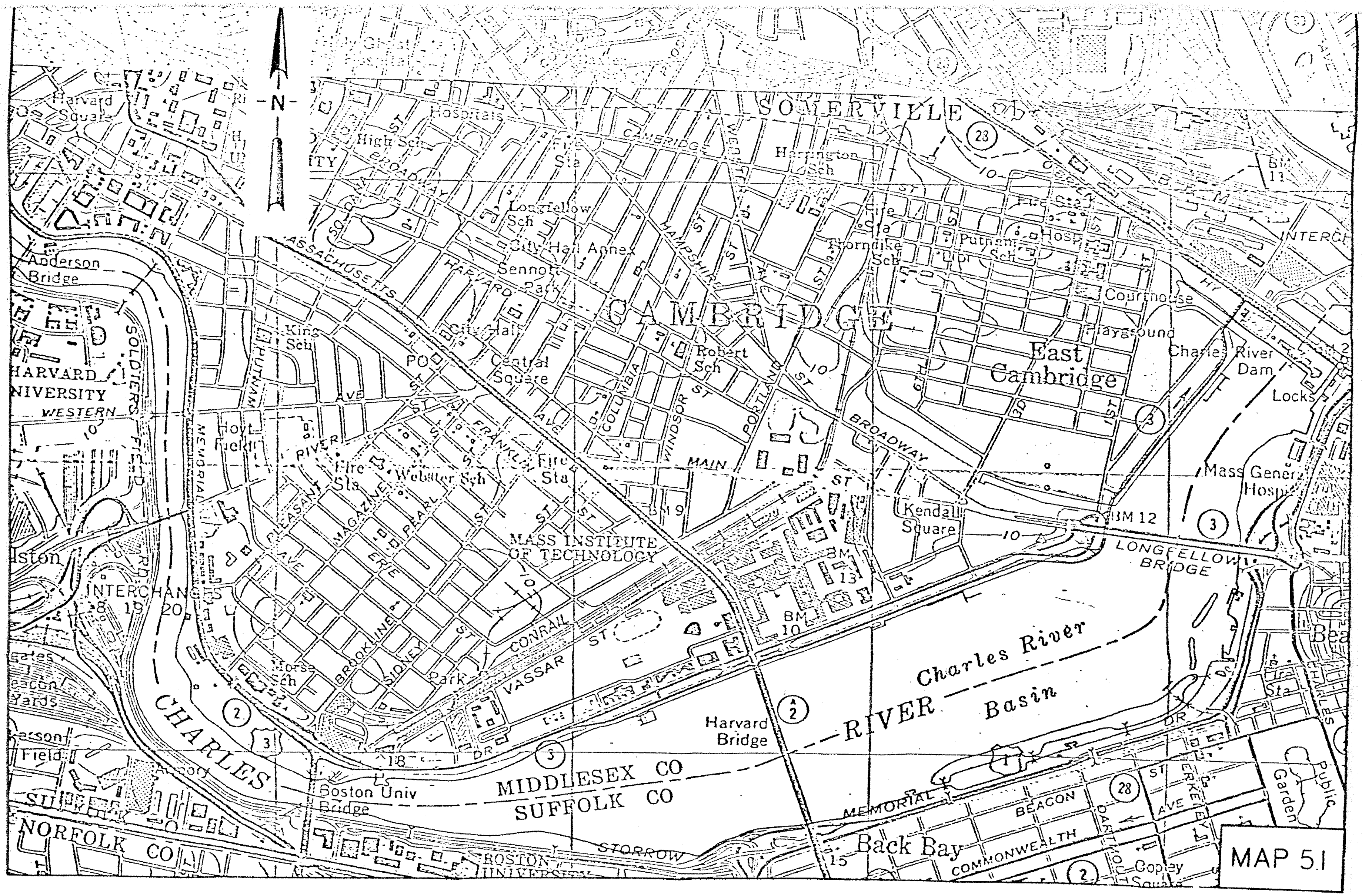

CHARLES RIVER
N
MILL DAM
MUDDY RIVER
CROSS DAM
BROOKLINE
BOSTON AND ALBANY RAILROAD
ORIGINAL SHORELINE
BROOKLINE
CHANNEL OF
FULL BASIN
GRAVELLY POINT
ORIGINAL
LONGWOOD STREAM
SHORELINE
MUDDY
MARSHES
ISLAND
UPLAND
MARSH
RIVER
ORIGINAL SHORELINE
GREAT CREEK
ROXBURY
MARSH
STONY
BROOK

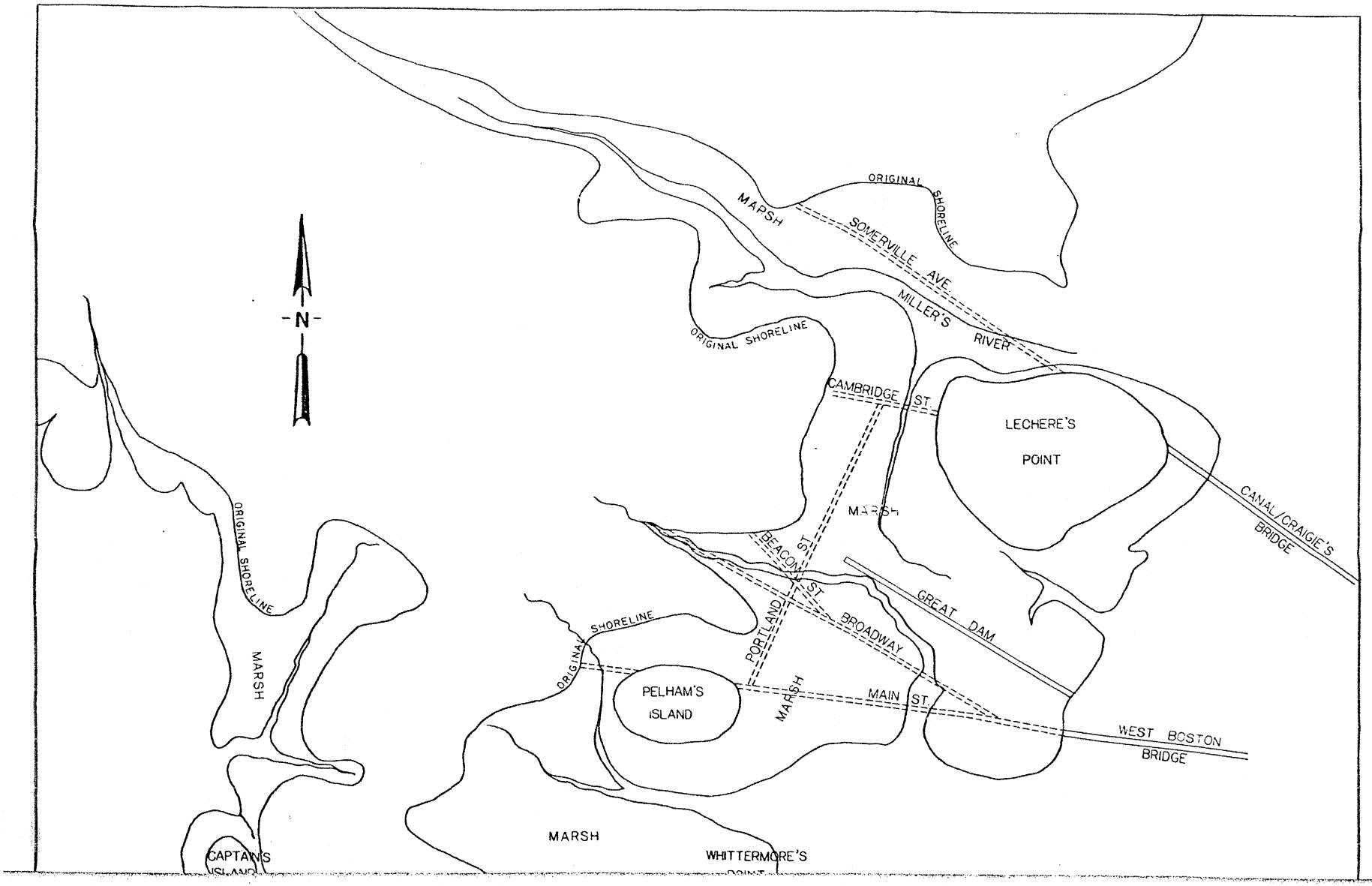
MAP 4.2


G
CHARLES RIVER
-N-
BROOKLINE ST.
SEAWALL C
SEAWALL B
SEAWALL A
F9
F3
F2
F5
F4
BEACON ENTRANCE
MASS AVE
BROOKLINE AVENUE
BOYLSTON ENTRANCE
F7
F6
PARK
WESTLAND ENTRANCE
F8
EMBANKMENT
ROADWAY
BACK BAY
FENWAY
HUNTINGTON ENTRANCE
TREMONT ENTRANCE
MAP 4.3

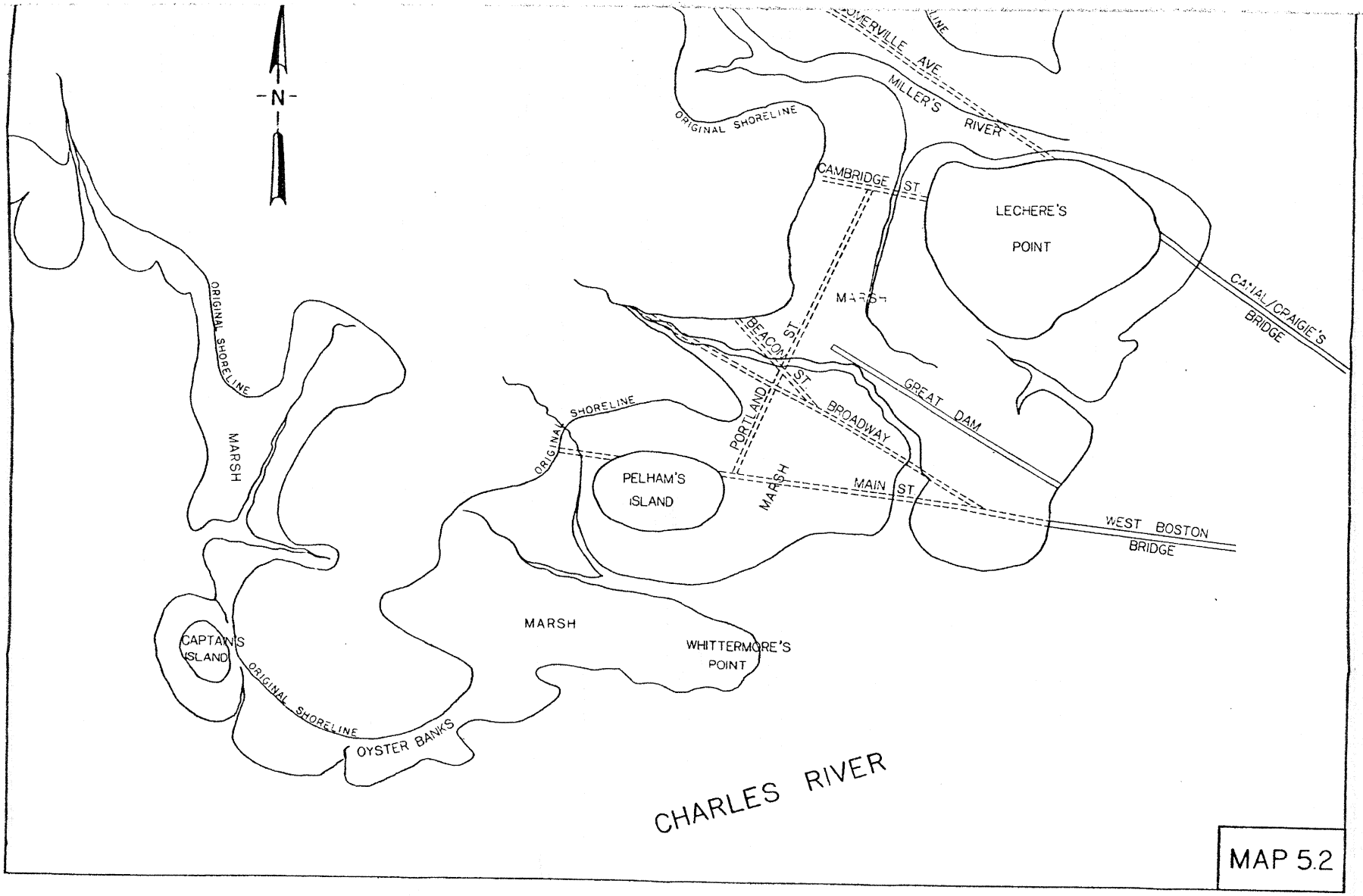

CAMBRIDGE
SOMERVILLE
CAMBRIDGE
East Cambridge
Harvard Square
Union Square
Central Square
Kendall Square
Harvard Bridge
Anderson Bridge
Longfellow Bridge
MASS INSTITUTE OF TECHNOLOGY
HARVARD UNIVERSITY
Charles River Dam
Mass General Hospital
Charles River
RIVER Basin
N

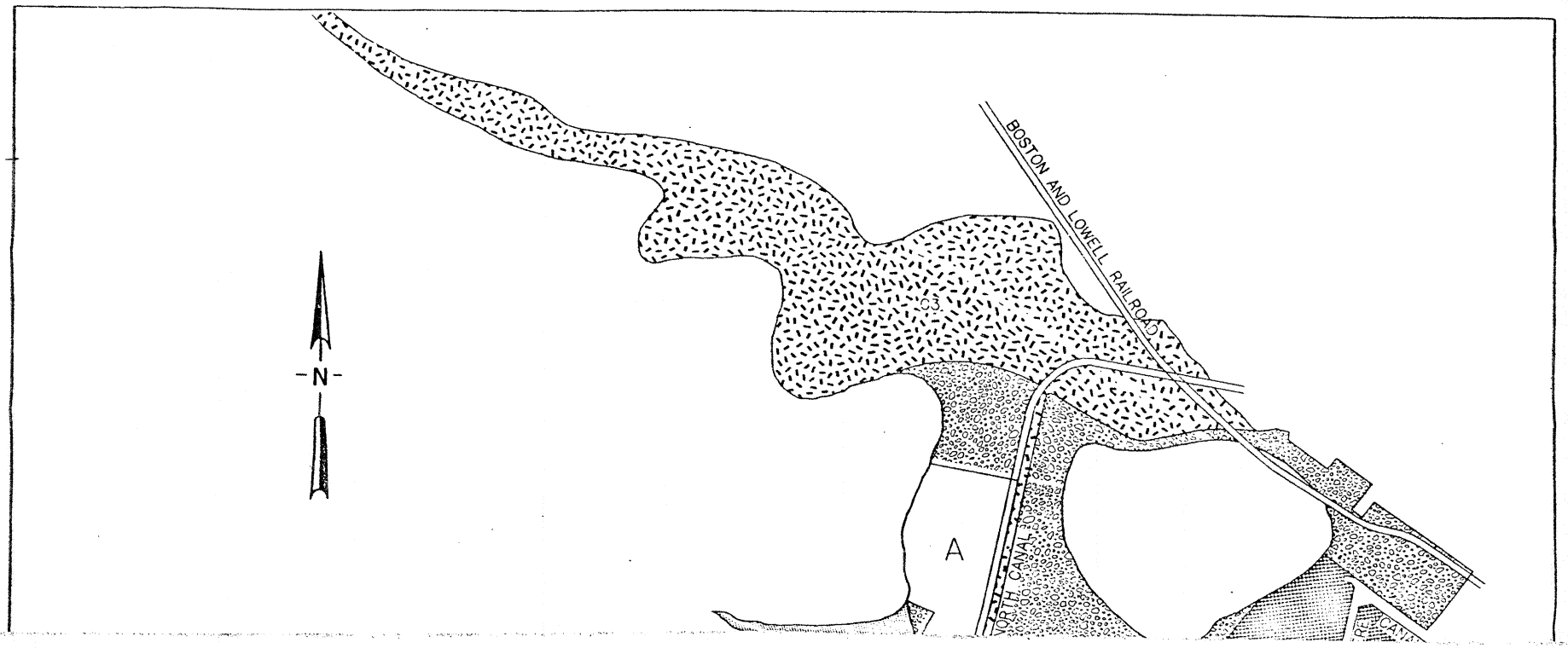
5.1

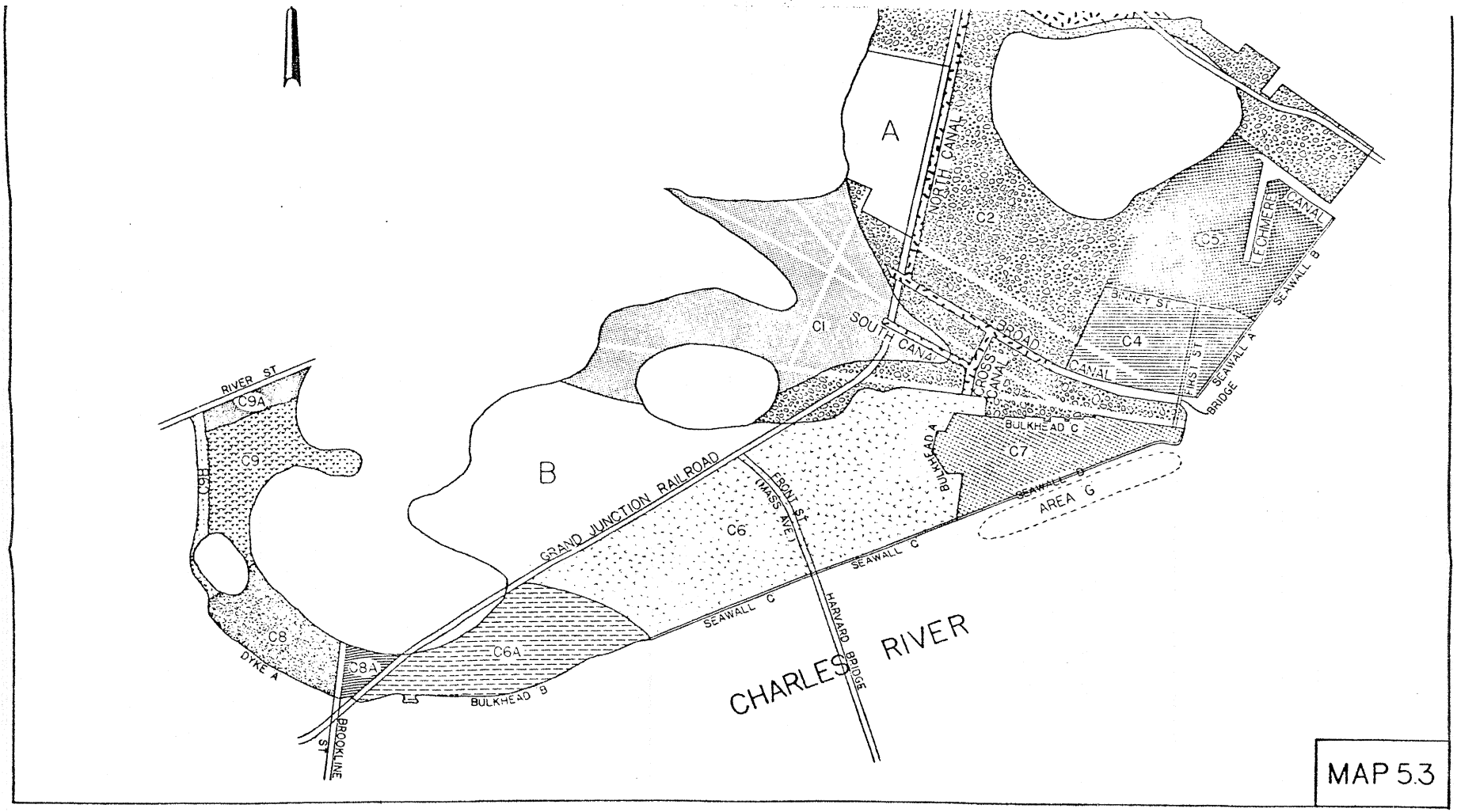

MAP 51
N
CAMBRIDGE
SOMERVILLE
East Cambridge
Charles River Basin
RIVER
CHARLES
MIDDLESEX CO
SUFFOLK CO
NORFOLK CO
Harvard Square
Anderson Bridge
HARVARD UNIVERSITY
SOLDIERS FIELD RD
WESTERN AVE
Hoyt Field
MEMORIAL DR
MASSACHUSETTS AVE
PUTNAM AVE
RIVER ST
King Sch
PO
Central Square
City Hall
City Hall Annex
Sennott Park
Longfellow Sch
HARVARD ST
BROADWAY
Hospitals
High Sch
CAMBRIDGE ST
HAMPSHIRE ST
Harrington Sch
Fire Sta
Thorndike Sch
Putnam Sch
Courthouse
Playground
Charles River Dam
Locks
Mass General Hosp
LONGFELLOW BRIDGE
BM 12
Kendall Square
MAIN ST
BROADWAY
PORTLAND ST
WINDSOR ST
COLUMBIA ST
Robert Sch
MASS INSTITUTE OF TECHNOLOGY
FRANKLIN ST
Fire Sta
Webster Sch
Fire Sta
PLEASANT ST
MAGAZINE ST
PEARL ST
ERIE ST
BROOKLINE ST
SIDNEY ST
Park
Morse Sch
CONRAIL
VASSAR ST
BM 9
BM 13
BM 10
Harvard Bridge
INTERCHANGE
Boston Univ Bridge
STORROW DR
BOSTON UNIVERSITY
MEMORIAL DR
BEACON ST
COMMONWEALTH AVE
DARTMOUTH ST
BERKELEY ST
Back Bay
Copley Square
Public Garden
CHARLES ST


N
MARSH
ORIGINAL SHORELINE
SOMERVILLE AVE.
MILLER'S RIVER
ORIGINAL SHORELINE
CAMBRIDGE ST.
LECHERE'S POINT
CANAL/CRAIGIE'S BRIDGE
MARSH
BEACON ST.
GREAT DAM
ORIGINAL SHORELINE
PORTLAND
BROADWAY
ORIGINAL SHORELINE
MARSH
PELHAM'S ISLAND
MAIN ST.
WEST BOSTON BRIDGE
ORIGINAL SHORELINE
MARSH
CAPTAIN'S ISLAND
MARSH
WHITTEMORE'S

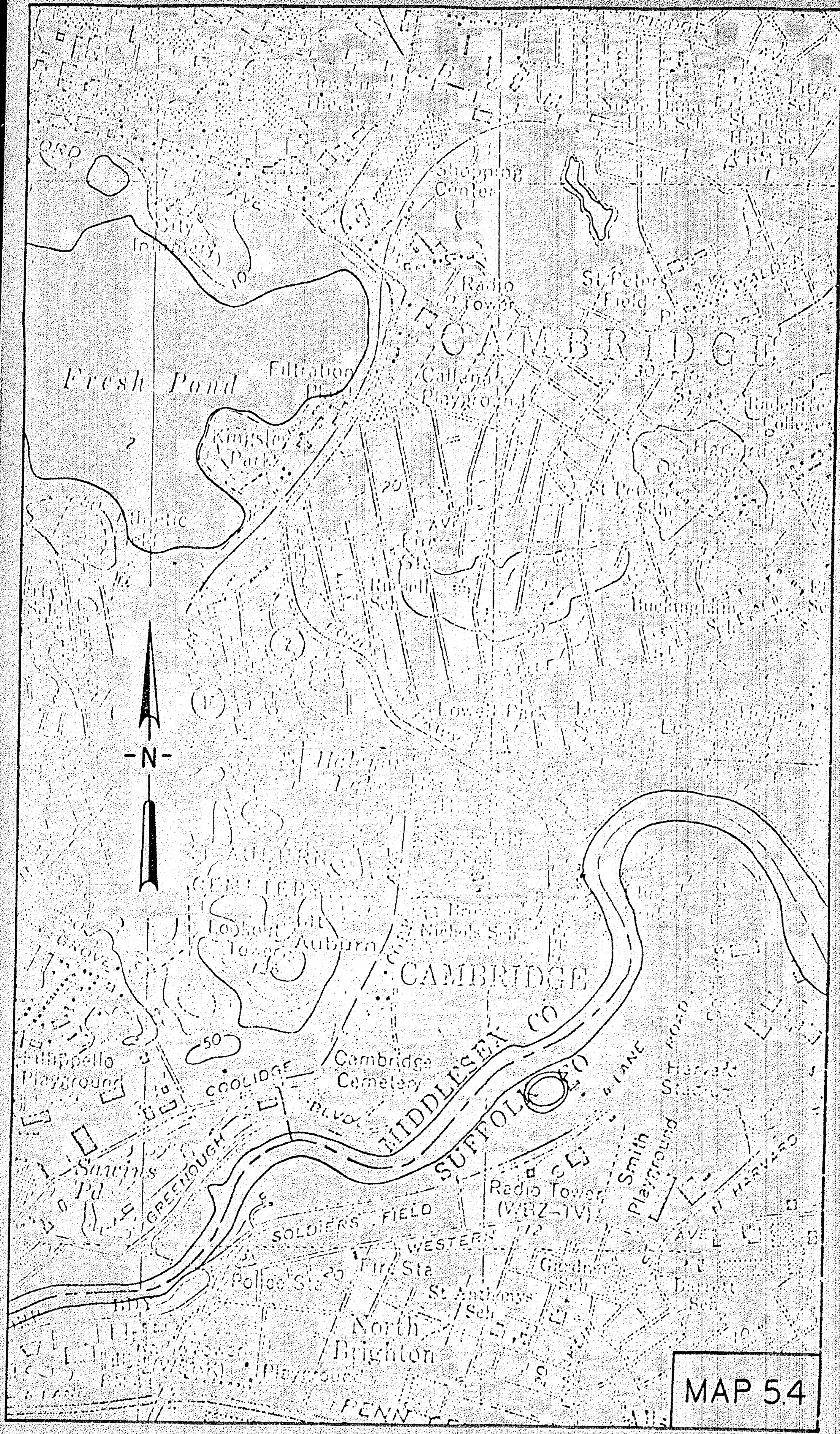
5.2


N
SOMERVILLE AVE
MILLER'S RIVER
ORIGINAL SHORELINE
CAMBRIDGE ST
LECHERE'S POINT
CANAL/CRAIGIE'S BRIDGE
MARSH
BEACON ST
PORTLAND ST
BROADWAY
GREAT DAM
ORIGINAL SHORELINE
PELHAM'S ISLAND
MARSH
MAIN ST
WEST BOSTON BRIDGE
ORIGINAL SHORELINE
MARSH
CAPTAIN'S ISLAND
WHITTEMORE'S POINT
ORIGINAL SHORELINE
OYSTER BANKS
CHARLES RIVER
MAP 5.2

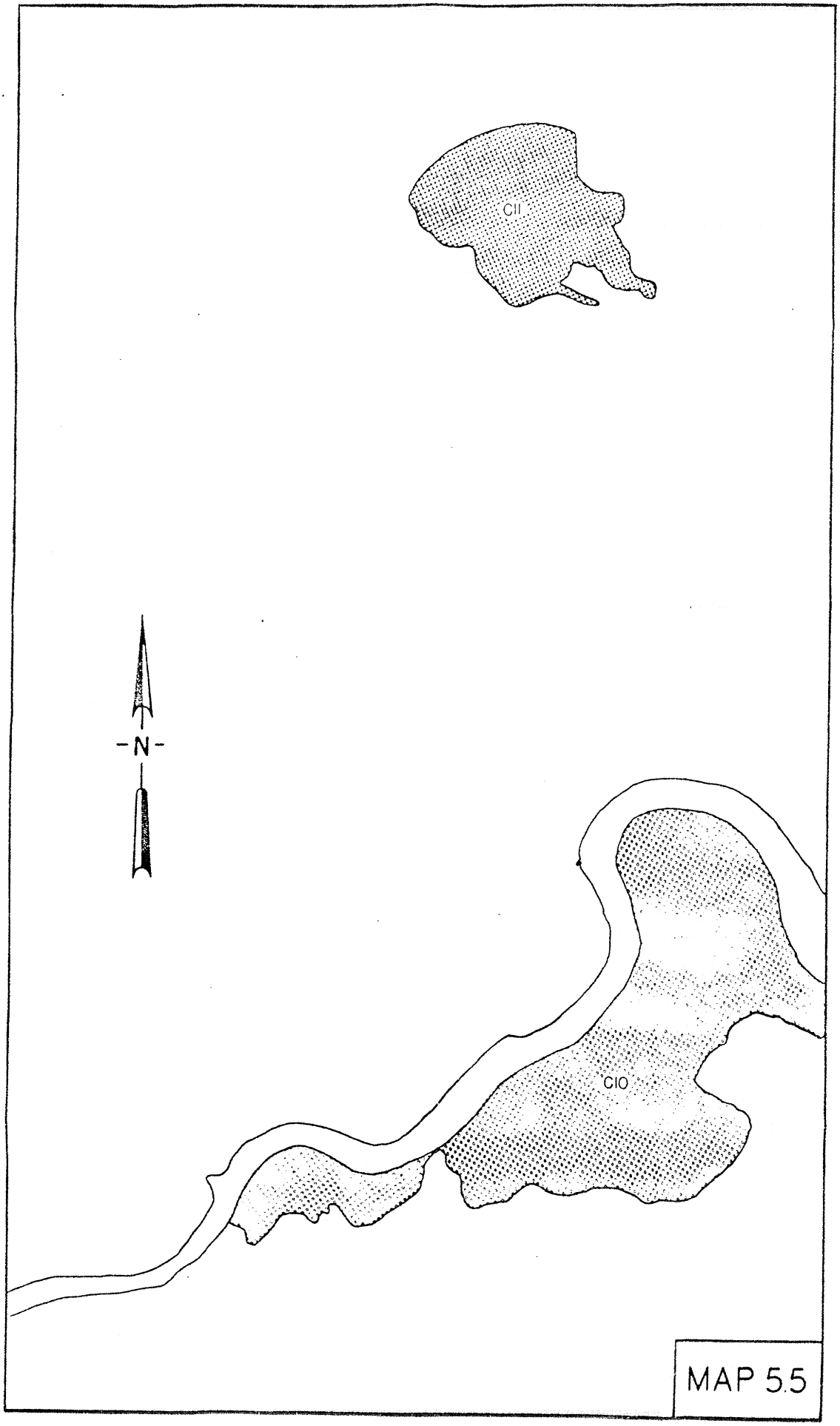

N
BOSTON AND LOWELL RAILROAD
A

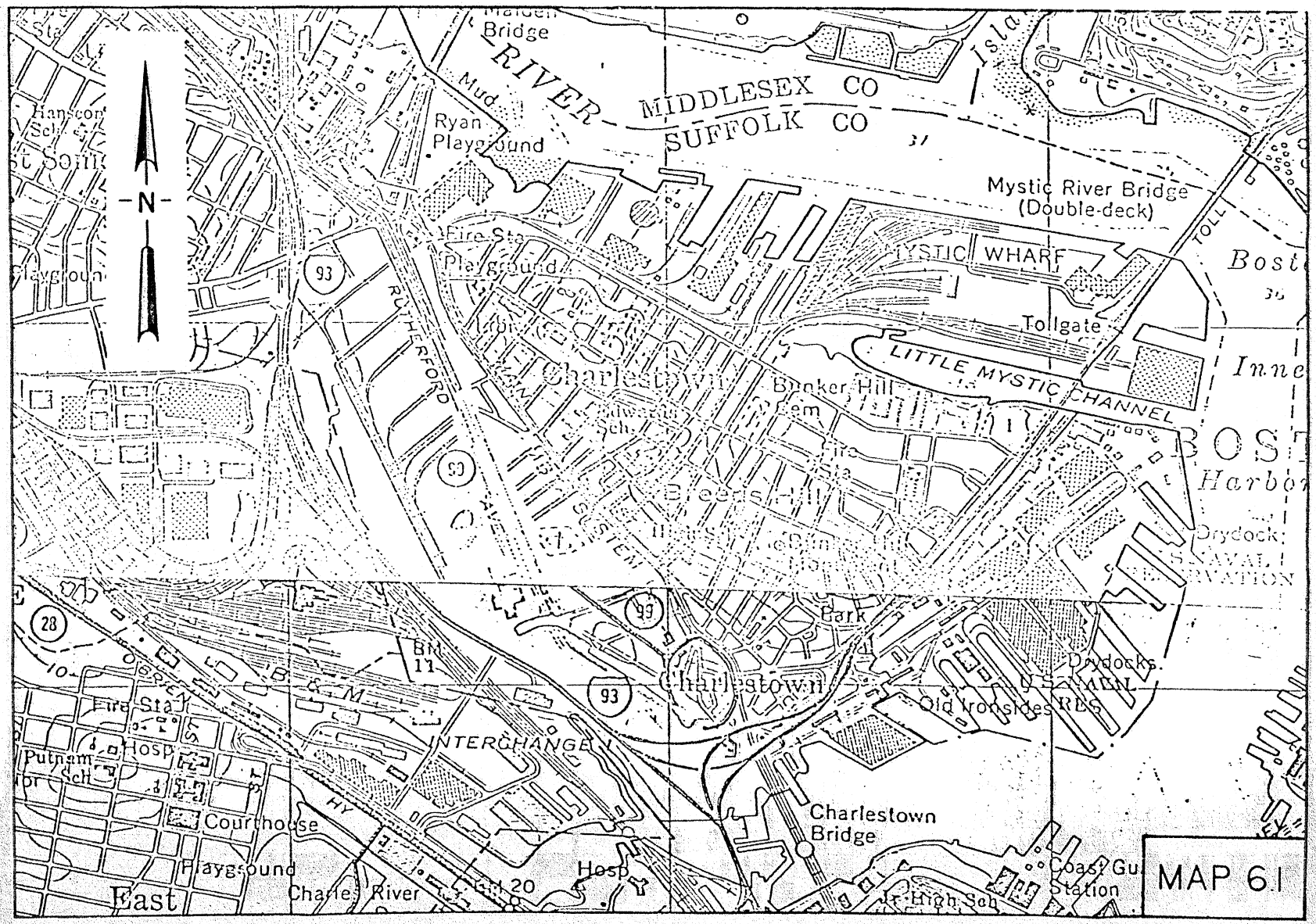

A
B
C1
C2
C3
C4
C5
C6
C7
C8
C8A
C9
C9A
C64
NORTH CANAL
SOUTH CANAL
CROSS CANAL
CANAL
BROAD
BINNEY ST.
HST ST.
TECHMERE CANAL
SEAWALL A
SEAWALL B
SEAWALL C
BRIDGE
BULKHEAD A
BULKHEAD B
BULKHEAD C
RIVER ST
DYKE A
H&D
GRAND JUNCTION RAIL ROAD
FRONT ST.
MASS AVE.
HARVARD BRIDGE
BROOKLINE ST.
AREA G
CHARLES RIVER

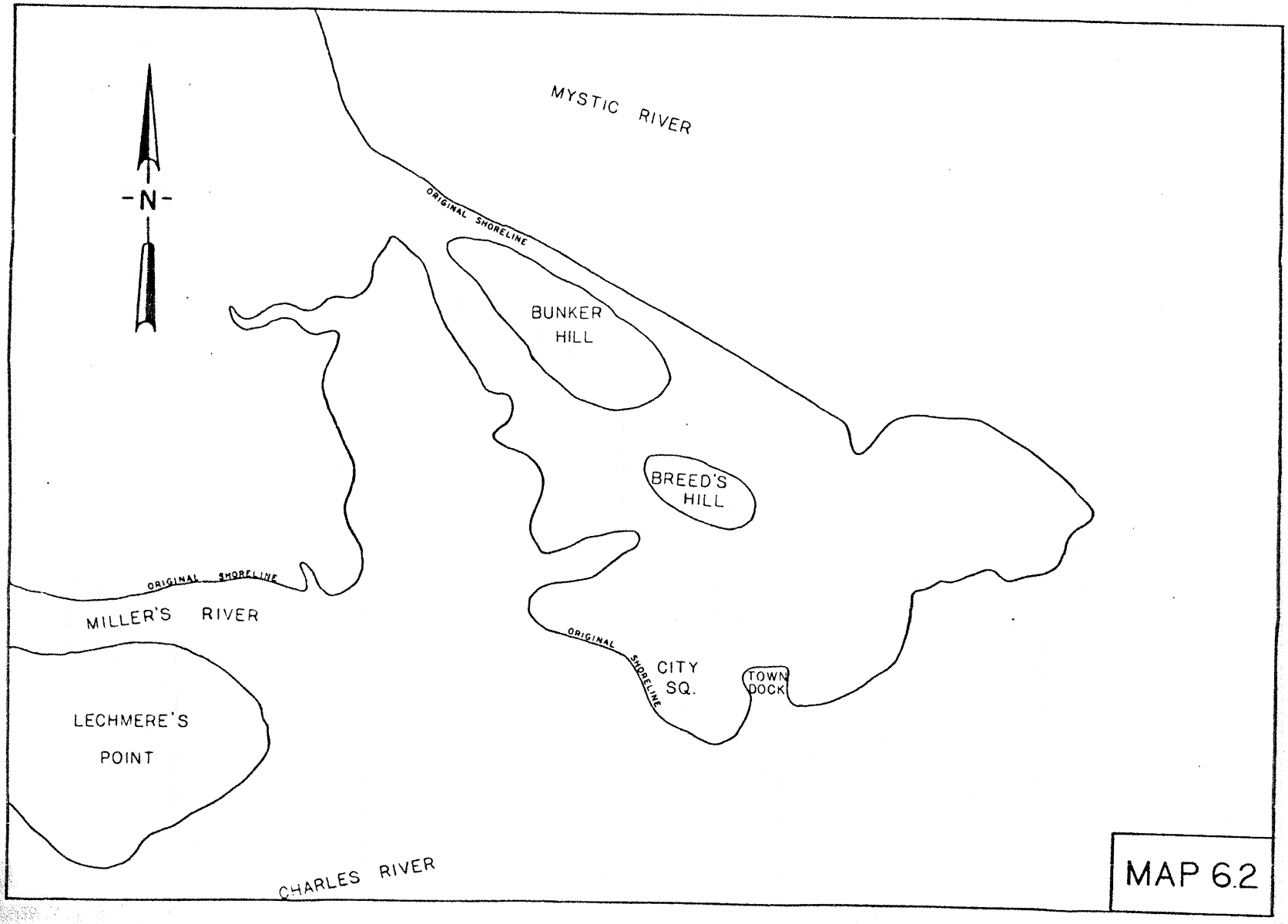
MAP 5.3

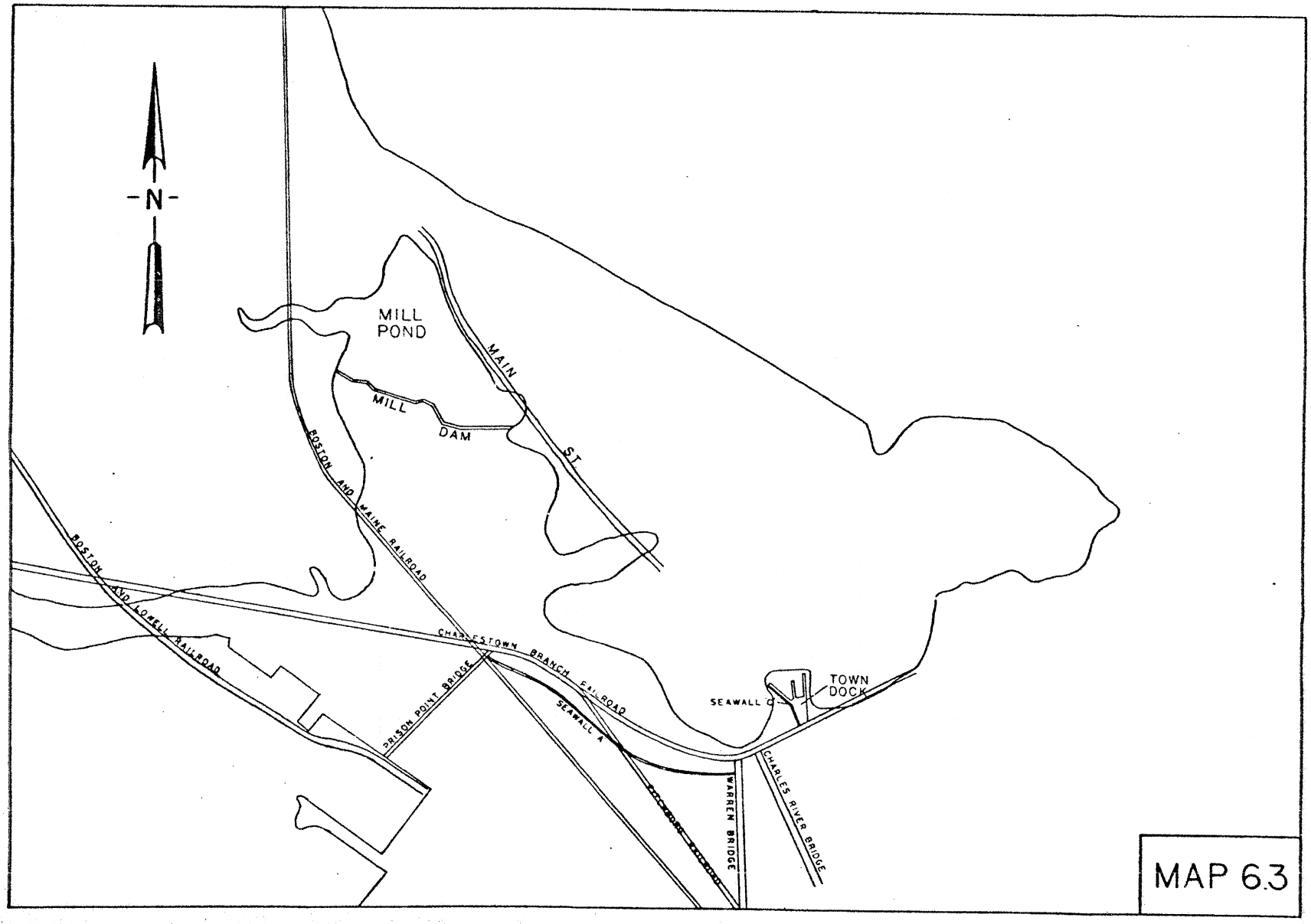

Fresh Pond
Filtration Plant
Shopping Center
Radio Tower
St Peters Field
CAMBRIDGE
Radcliffe College
Kingsley Park
Athletic
Russell Sch
Buckingham Sch
Lowell Park
Lowell Sch
N
Lookout Tower
Mt Auburn
CAMBRIDGE
MIDDLESEX CO
SUFFOLK CO
Cambridge Cemetery
COOLIDGE
BLVD
GREENOUGH
Playground
Harvard Stadium
Smith Playground
Radio Tower (WBZ-TV)
SOLDIERS FIELD
WESTERN
AVE
Fire Sta
Police Sta
St Anthonys Sch
North Brighton
PENN

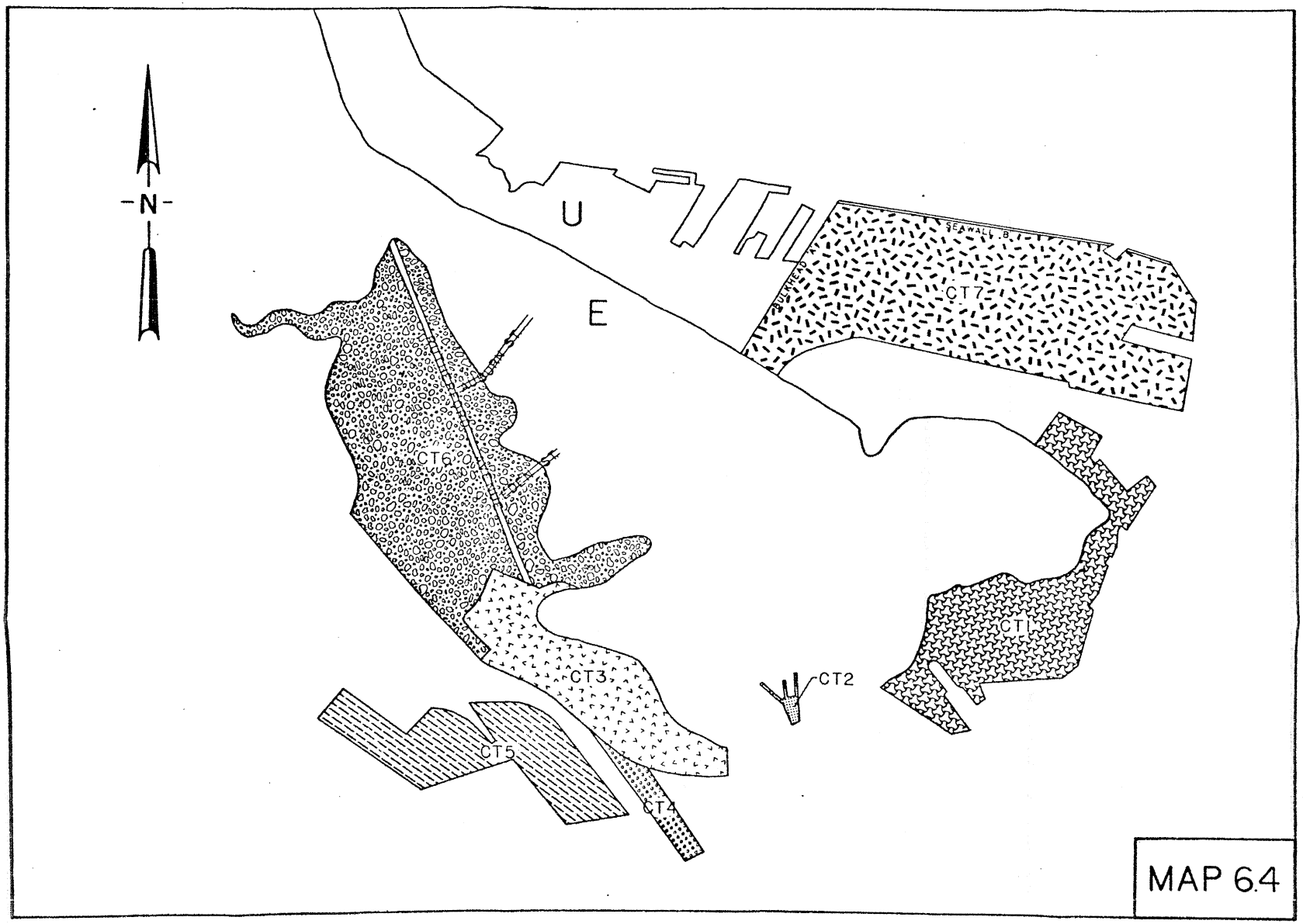
MAP 5.4


CII
N
CIO
MAP 5.5

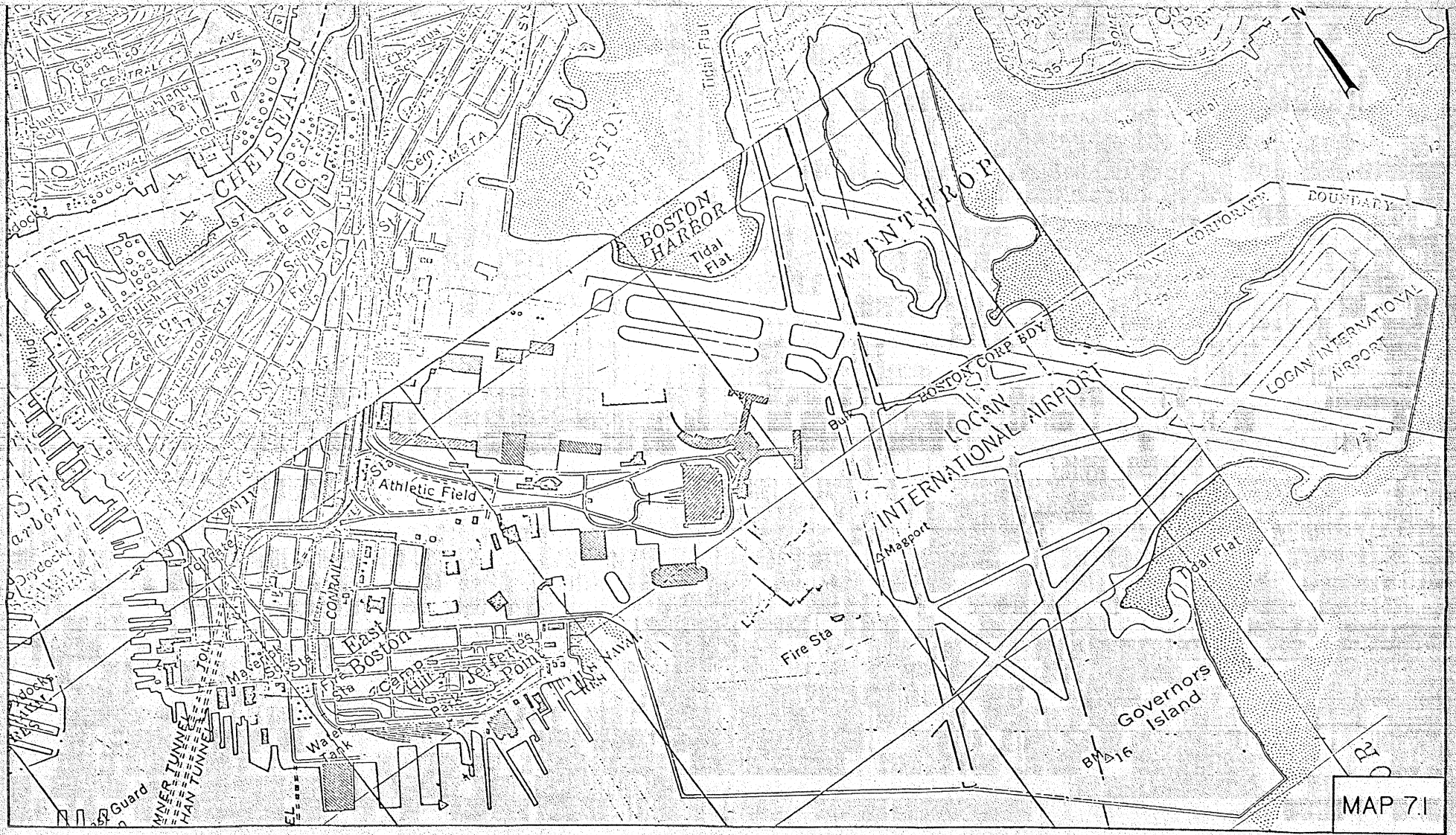

Bridge
RIVER
MIDDLESEX CO
SUFFOLK CO
Mystic River Bridge
(Double-deck)
Ryan
Playground
Fire Sta
Playground
MYSTIC WHARF
Tollgate
LITTLE MYSTIC CHANNEL
Bunker Hill
Fire Sta
Drydock
Harbor
Bark
Drydocks
Old Ironsides
INTERCHANGE
Fire Sta
Hosp
Courthouse
Playground
East
Charles River
Hosp
Charlestown
Bridge
Jr High Sch
Coast Gu
Station
MAP 61

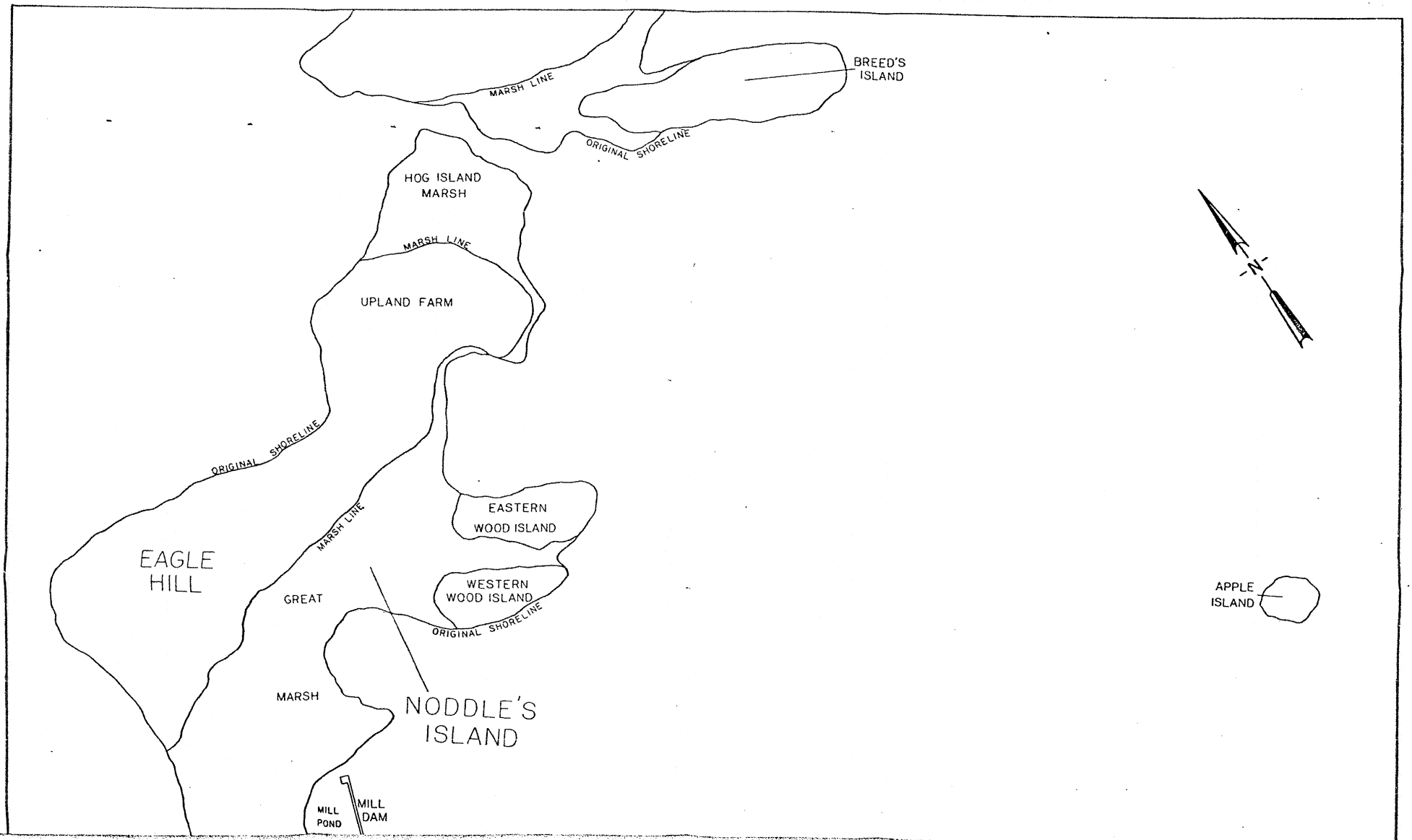

MYSTIC RIVER
-N-
ORIGINAL SHORELINE
BUNKER HILL
BREED'S HILL
ORIGINAL SHORELINE
MILLER'S RIVER
ORIGINAL SHORELINE
CITY SQ.
TOWN DOCK
LECHMERE'S POINT
CHARLES RIVER
MAP 6.2

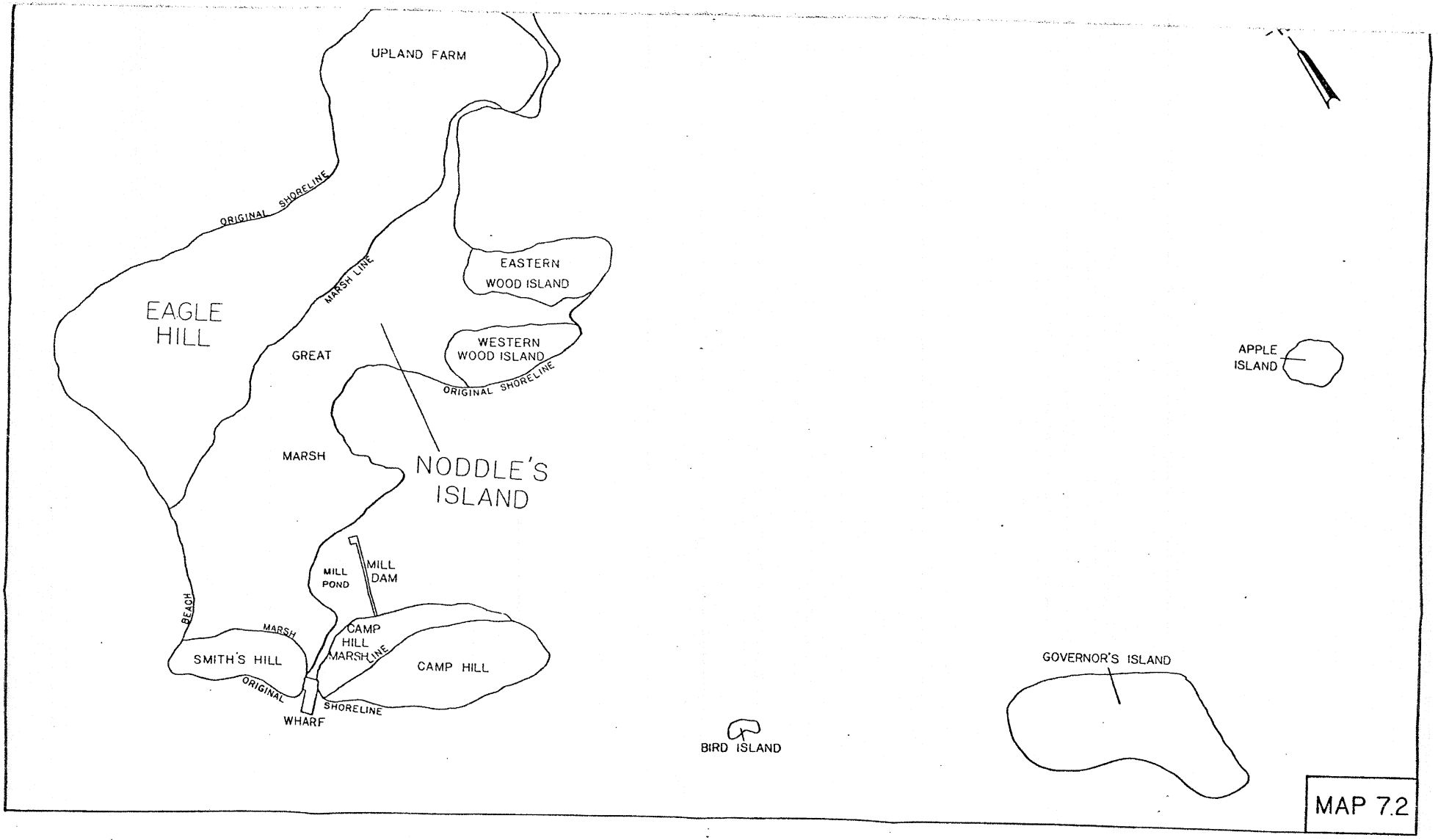

N
MILL POND
MILL DAM
MAIN ST.
BOSTON AND MAINE RAILROAD
BOSTON AND LOWELL RAILROAD
CHARLESTOWN BRANCH RAILROAD
PRISON POINT BRIDGE
SEAWALL A
SEAWALL C
TOWN DOCK
WARREN BRIDGE
CHARLES RIVER BRIDGE
MAP 6.3

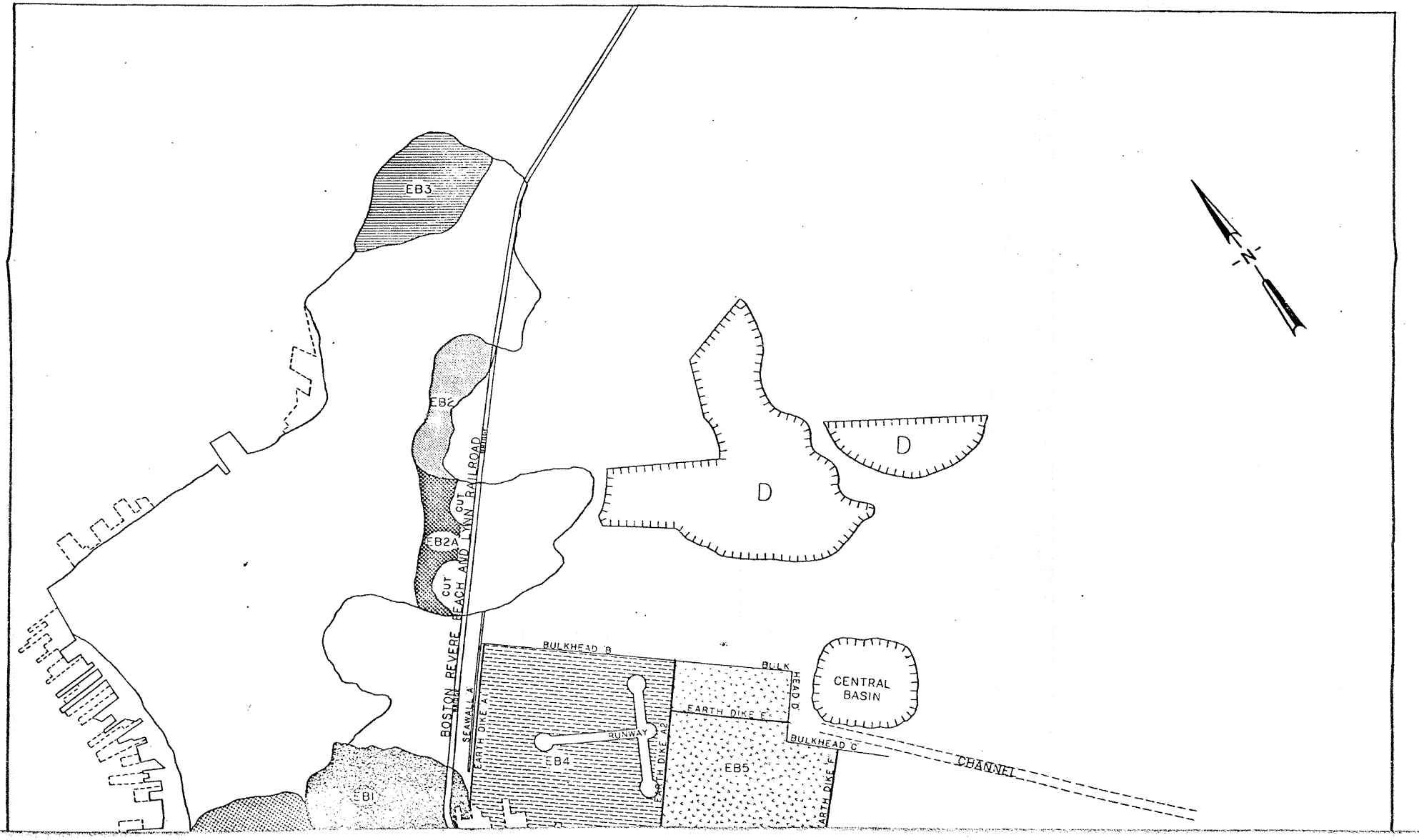

N
U
E
SEAWALL B
BULKHEAD A
CT7
CT6
CT3
CT5
CT4
CT2
CT1
MAP 6.4

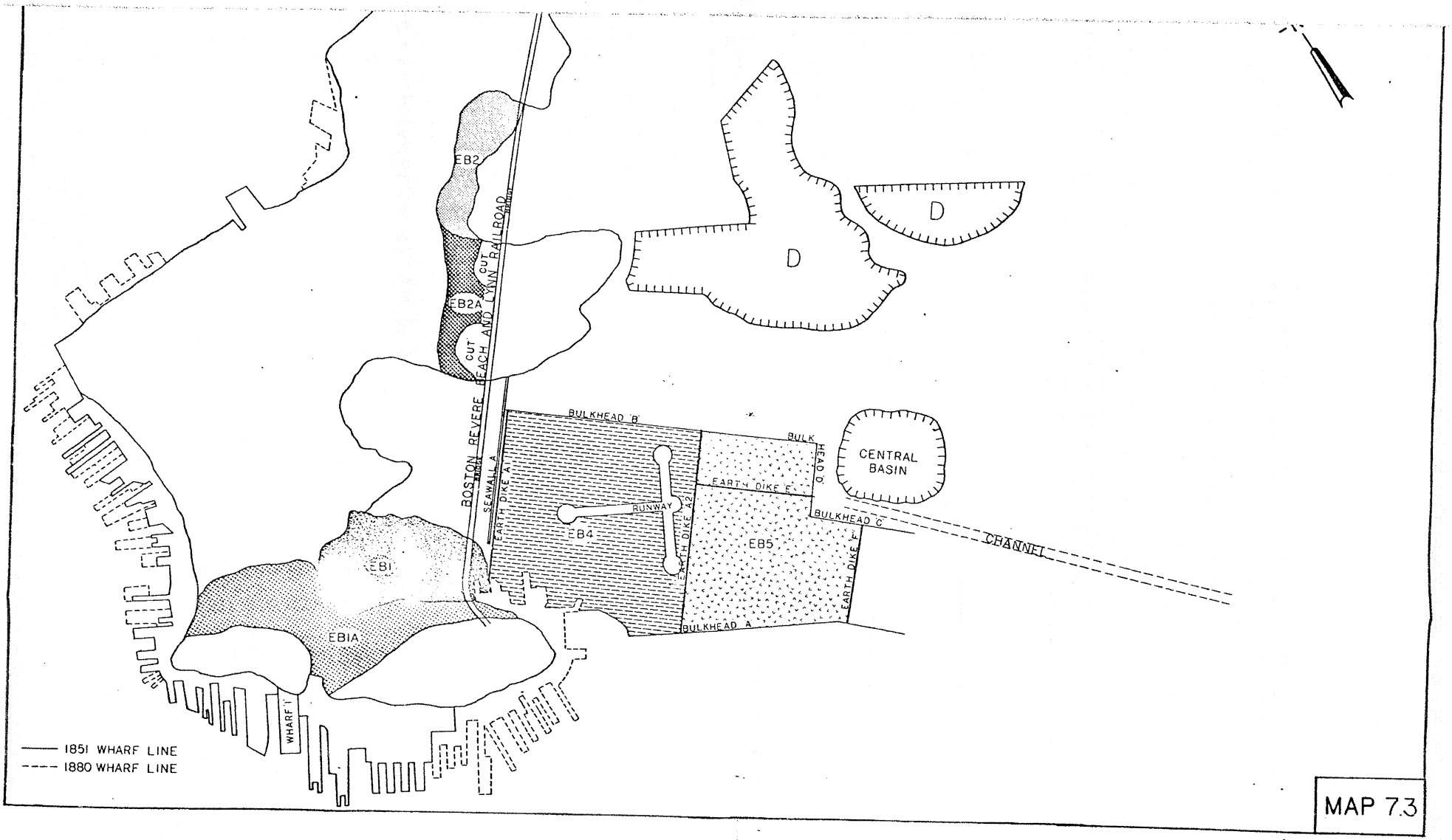
LOGAN INTERNATIONAL AIRPORT
INTERNATIONAL LOGAN AIRPORT
BOSTON CORP BDY
WINTHROP
BOSTON HARBOR
HARBOR
Tidal Flat
Athletic Field
CHELSEA
Mud

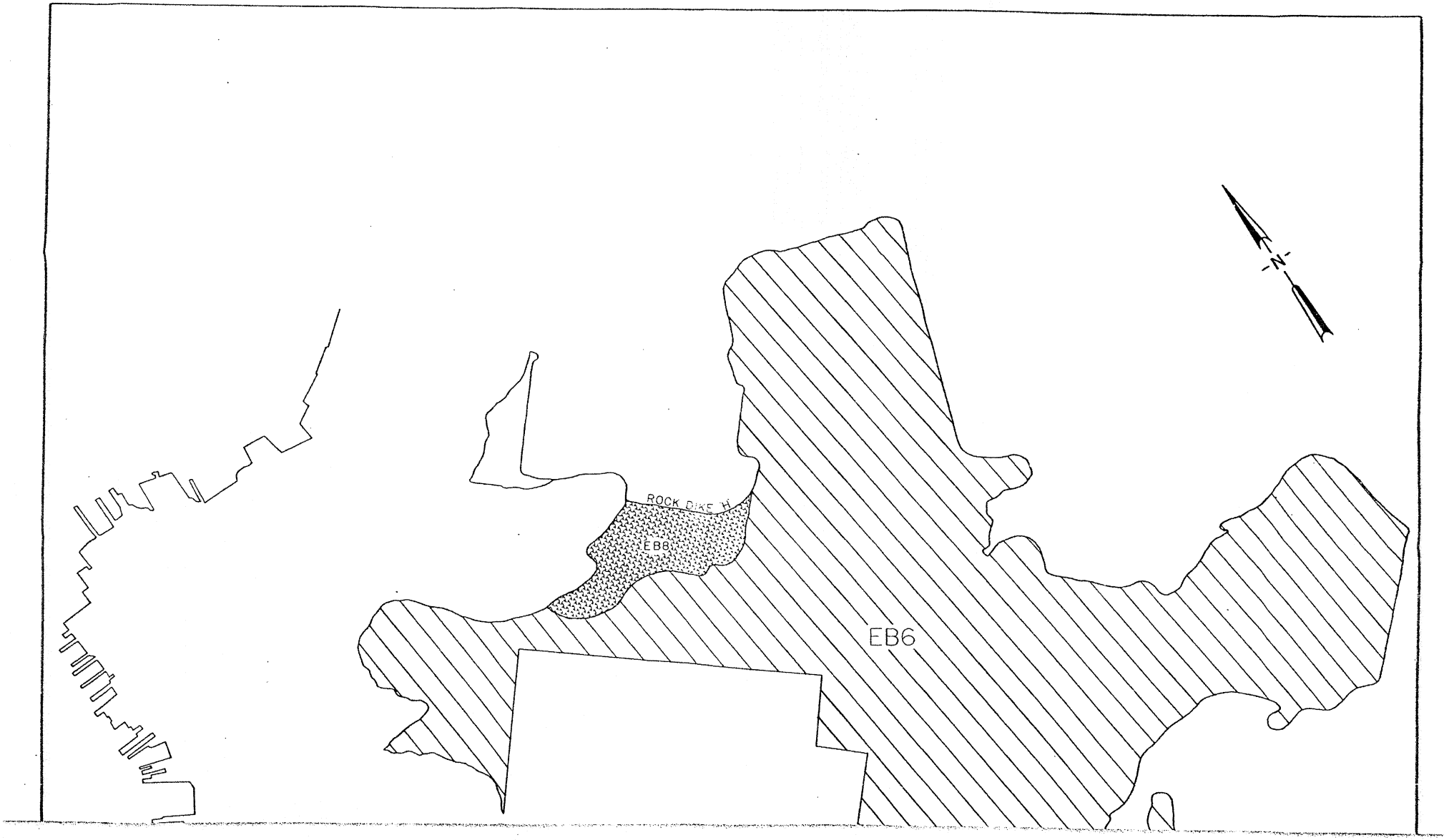

CHELSEA
BOSTON
WINTHROP
BOSTON HARBOR
Tidal Flat
Tidal Flat
BOUNDARY
LOGAN INTERNATIONAL AIRPORT
LOGAN INTERNATIONAL AIRPORT
BOSTON CORP BDY
Athletic Field
Maypart
Fire Sta
East Boston
Camp Hill
Jeffries Point
Tidal Flat
Governors Island
Water Tank
MINER TUNNEL
HAN TUNNEL
Guard
BM 16
N
MAP 7.1


BREED'S ISLAND
MARSH LINE
ORIGINAL SHORELINE
HOG ISLAND MARSH
MARSH LINE
UPLAND FARM
ORIGINAL SHORELINE
EASTERN WOOD ISLAND
MARSH LINE
EAGLE HILL
GREAT
WESTERN WOOD ISLAND
ORIGINAL SHORELINE
APPLE ISLAND
MARSH
NODDLE'S ISLAND
MILL POND
MILL DAM

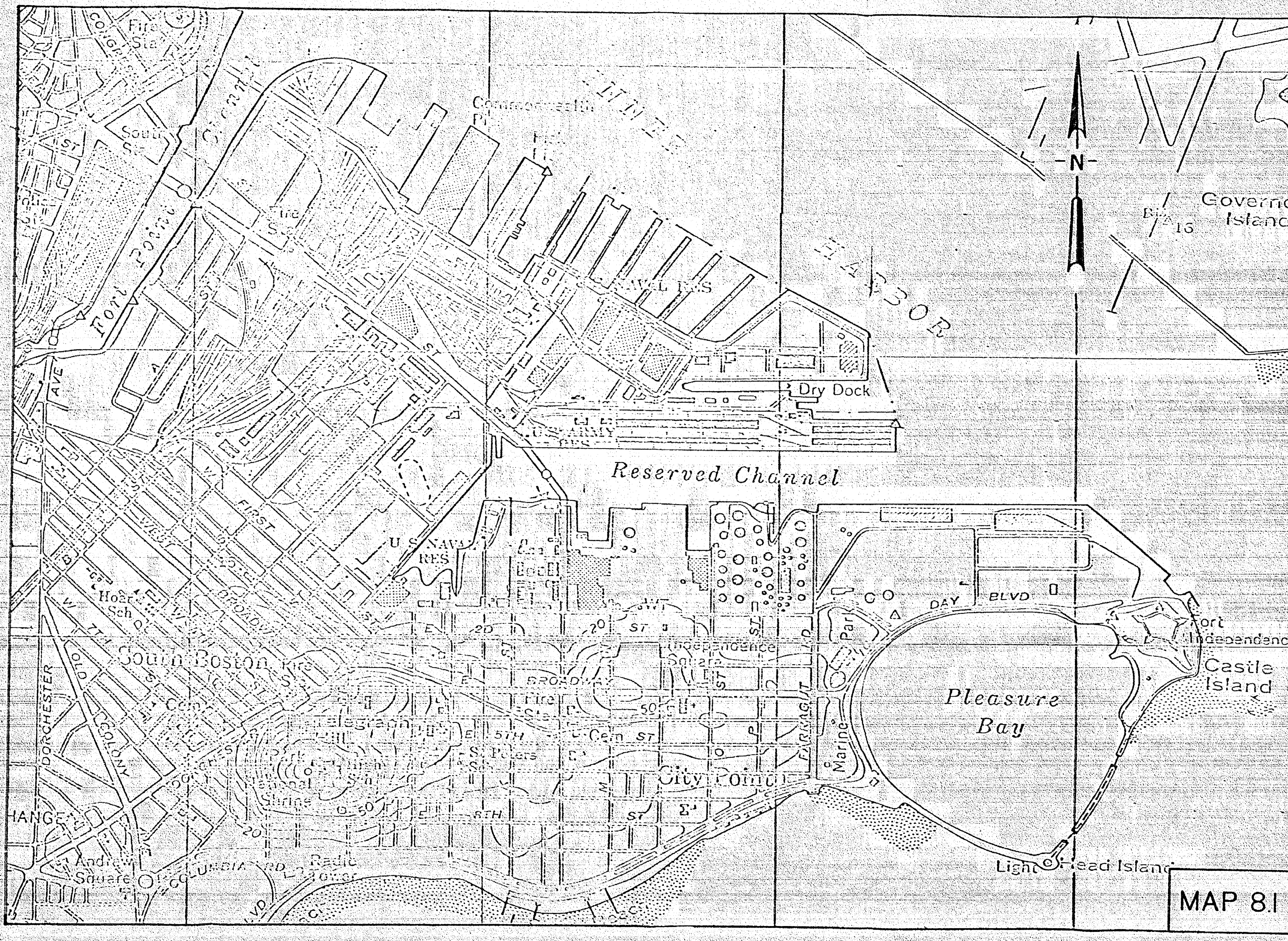

UPLAND FARM
ORIGINAL SHORELINE
MARSH LINE
EASTERN WOOD ISLAND
EAGLE HILL
GREAT
WESTERN WOOD ISLAND
ORIGINAL SHORELINE
APPLE ISLAND
MARSH
NODDLE'S ISLAND
MILL POND
MILL DAM
BEACH
MARSH
CAMP HILL MARSH LINE
SMITH'S HILL
CAMP HILL
ORIGINAL
SHORELINE
WHARF
BIRD ISLAND
GOVERNOR'S ISLAND
MAP 7.2

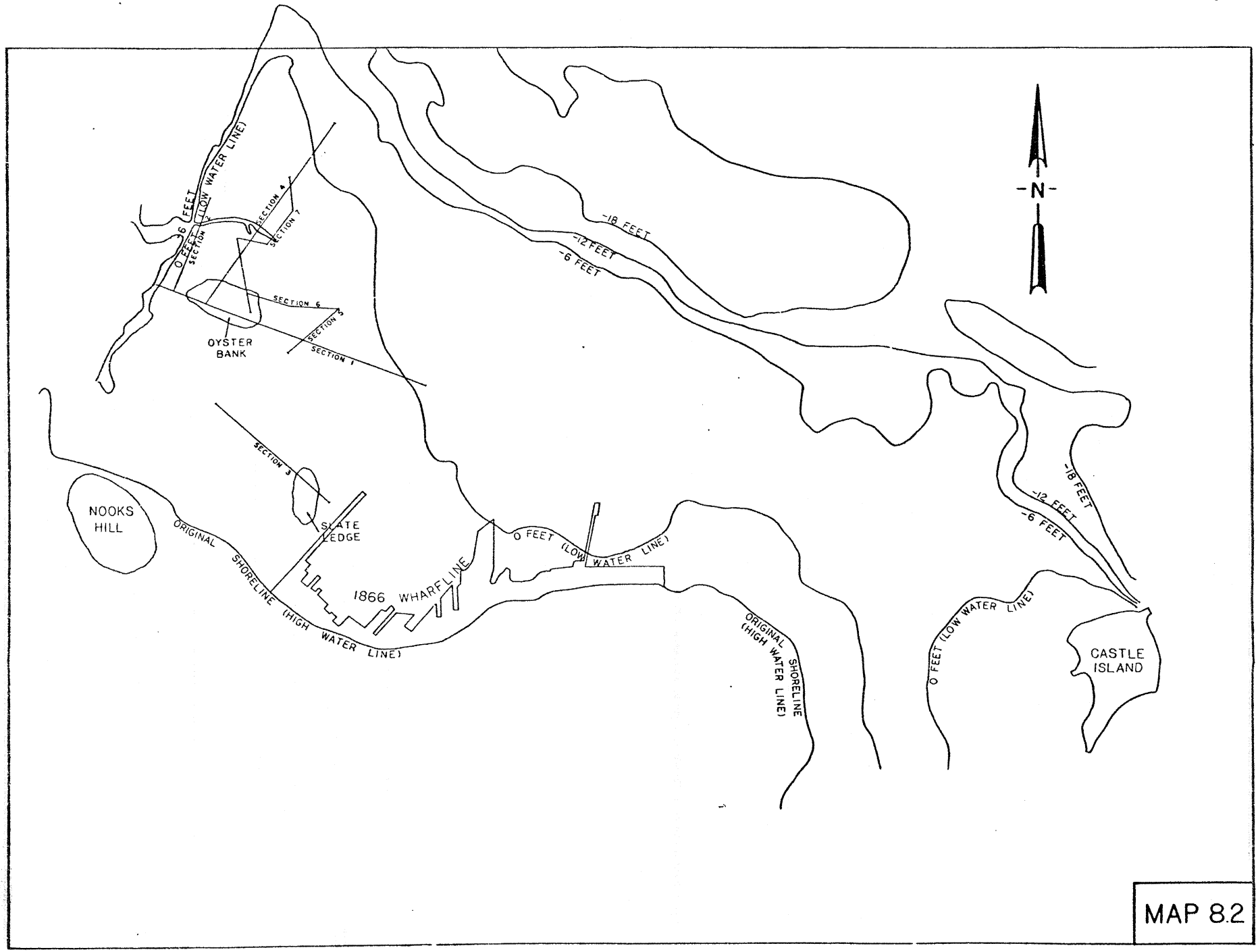

EB3
EB2
EB2A
CUT
CUT
BOSTON REVERE BEACH AND LYNN RAILROAD
D
D
BULKHEAD B
BULK
HEAD D
CENTRAL
BASIN
EARTH DIKE E
SEAWALL A
EARTH DIKE A1
RUNWAY
EARTH DIKE A2
BULKHEAD C
CHANNEL
EB4
EB5
EB1
EARTH DIKE F
N


EB2
EB2A
CUT
CUT
BOSTON REVERE BEACH AND LYNN RAILROAD
D
D
BULKHEAD B
BULK HEAD C
CENTRAL BASIN
SEAWALL A
EARTH DIKE A1
EARTH DIKE A2
EARTH DIKE E
RUNWAY
EB4
EB5
BULKHEAD C
CHANNEL
EARTH DIKE F
BULKHEAD A
EB1
EB1A
WHARF 1
1851 WHARF LINE
1880 WHARF LINE
MAP 7.3

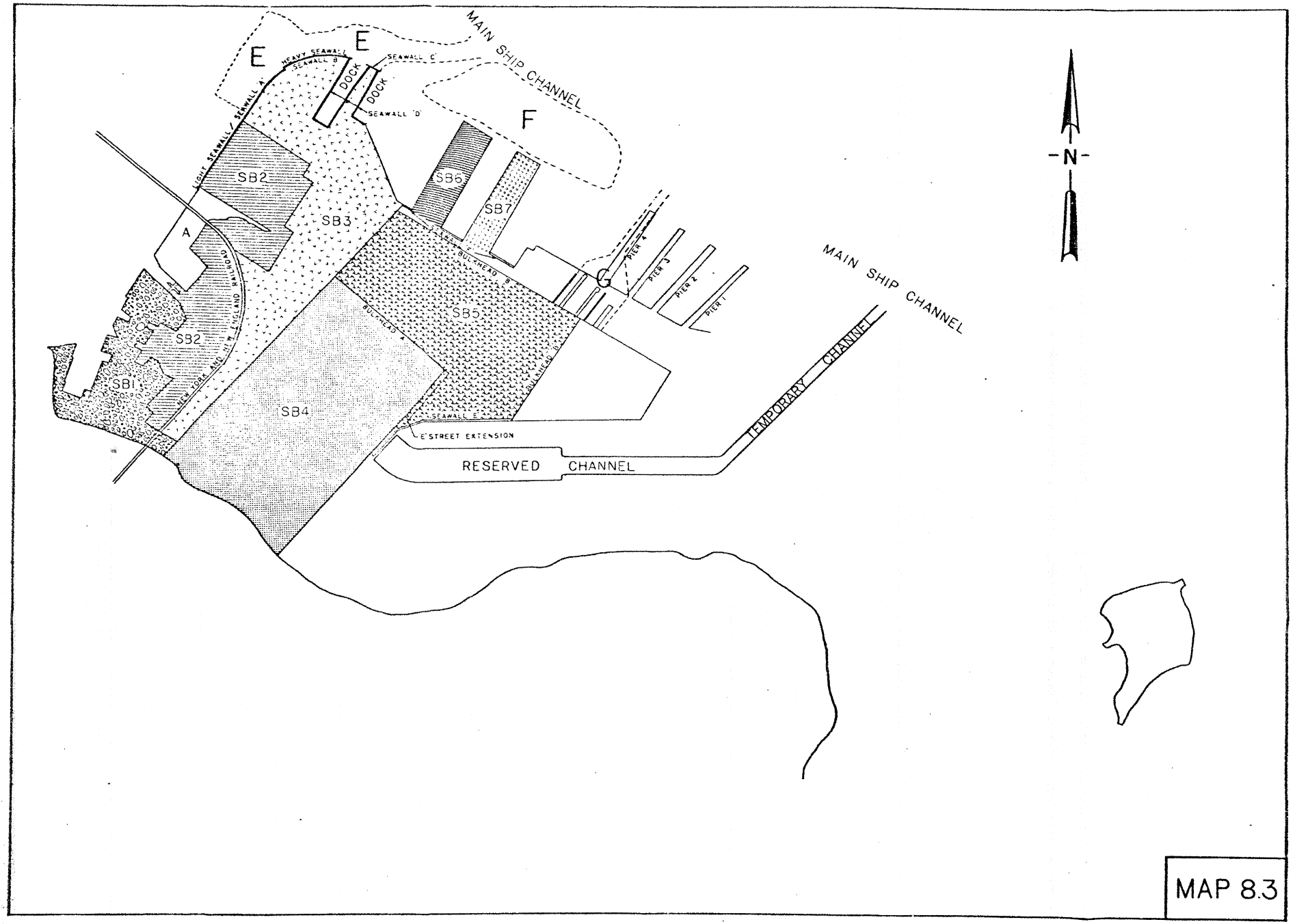

ROCK DIKE H
EB6
EB6

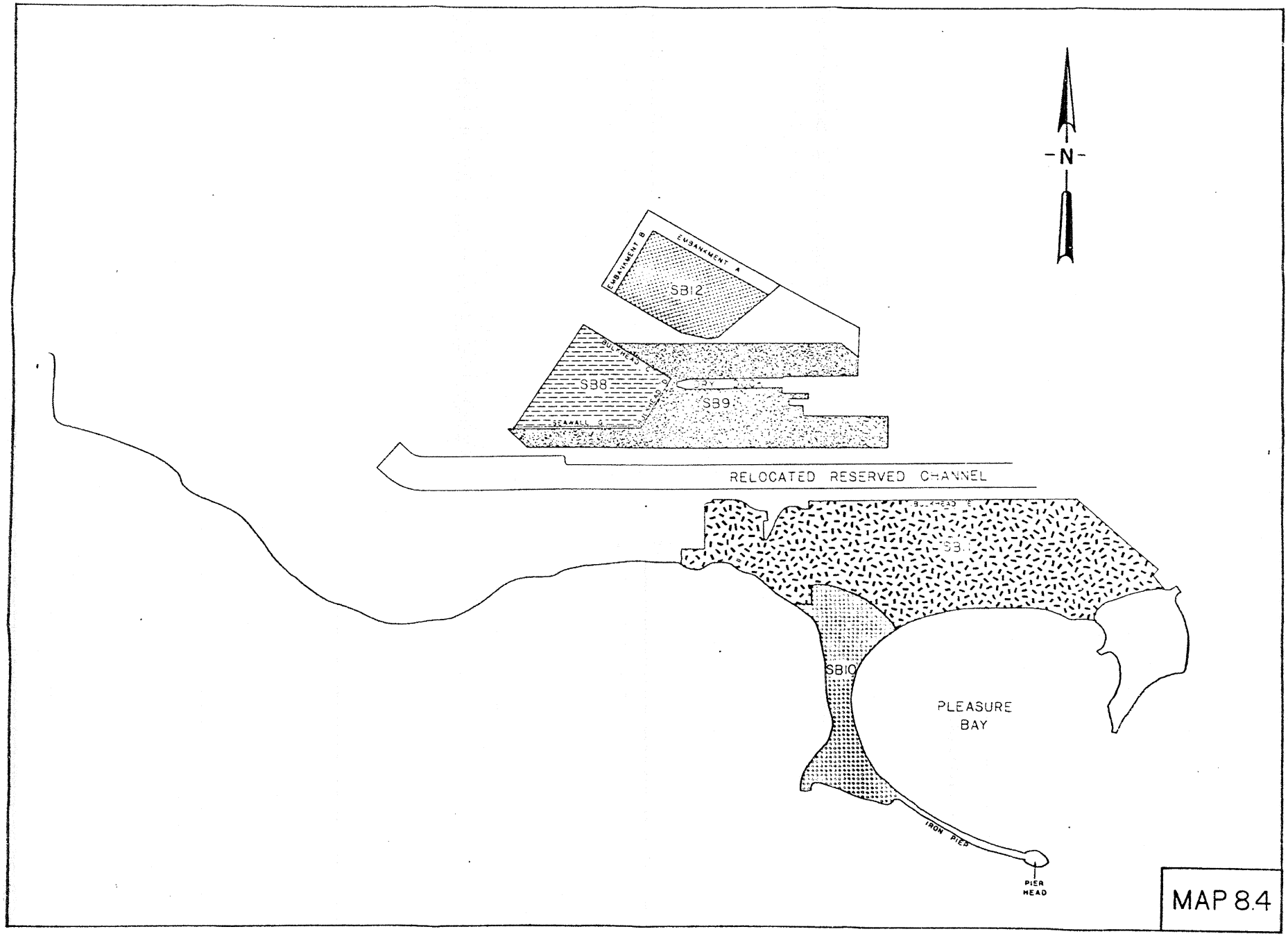

ROCK DIKE H
EB8
EB6
TODAY'S WHARF LINE
WHARF 2
WHARF 3
WHARF 4
WHARF 5
ROADWAY
ROCK DIKE G
MAP 7.4


N
Governor Island
Harbor
Commonwealth Pier
Fort Point Channel
South Sta
Fire Sta
Dry Dock
U S Army Res
Reserved Channel
U S Naval Res
Day Blvd
Fort Independence
Castle Island
Pleasure Bay
Marine Park
Farragut
Independence Square
Broadway
First
South Boston
Telegraph Hill
St Peters Sch
City Point
Light
Head Island
Dorchester Ave
Old Colony
Andrew Square
Columbia Rd
Radio Tower
MAP 8.1

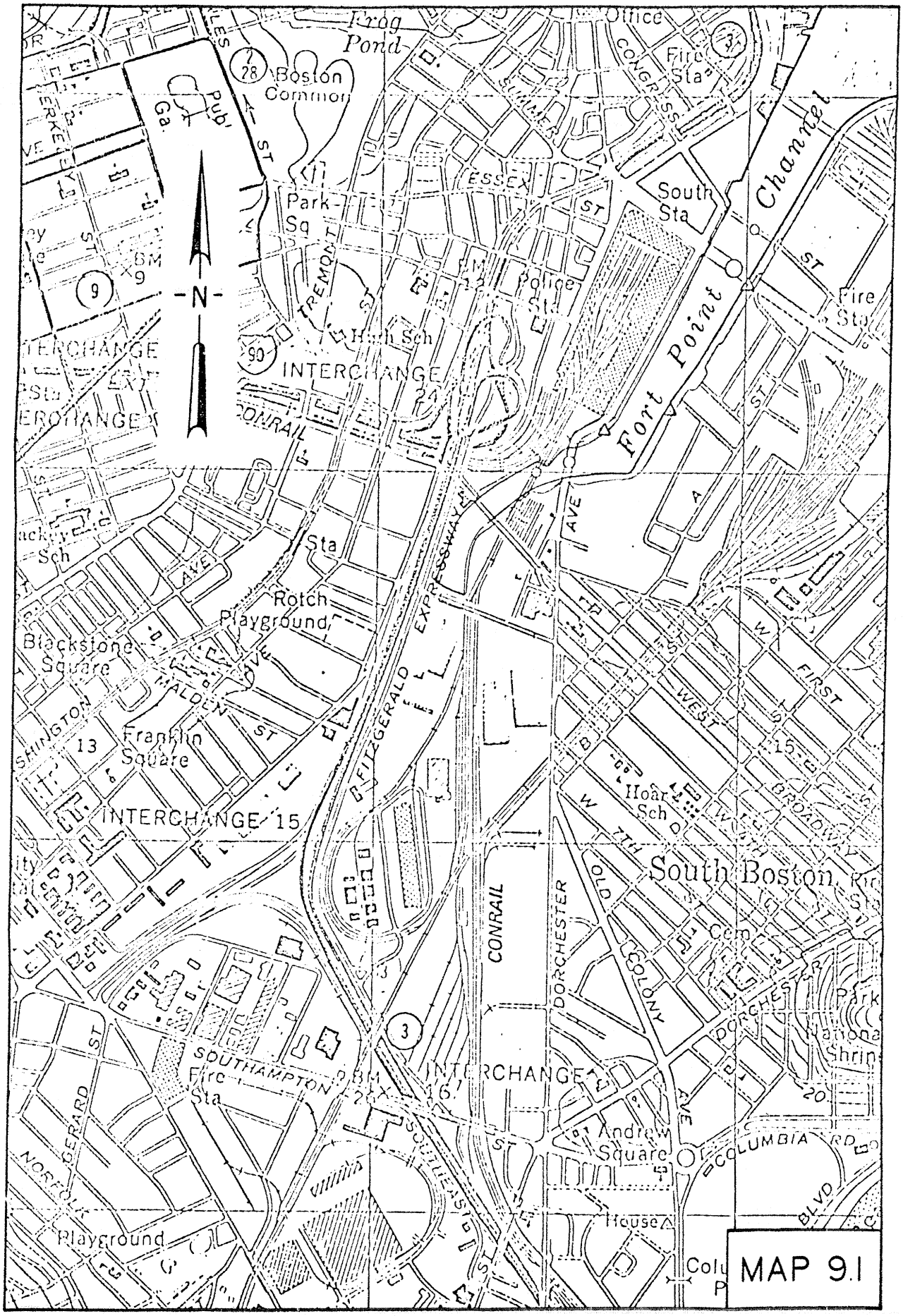

-6 FEET (LOW WATER LINE)
0 FEET
SECTION 4
SECTION 7
SECTION 6
SECTION 5
SECTION 1
OYSTER BANK
-18 FEET
-12 FEET
-6 FEET
N
SECTION 3
NOOKS HILL
SLATE LEDGE
ORIGINAL SHORELINE (HIGH WATER LINE)
1866 WHARFLINE
0 FEET (LOW WATER LINE)
ORIGINAL SHORELINE (HIGH WATER LINE)
-18 FEET
-12 FEET
-6 FEET
0 FEET (LOW WATER LINE)
CASTLE ISLAND

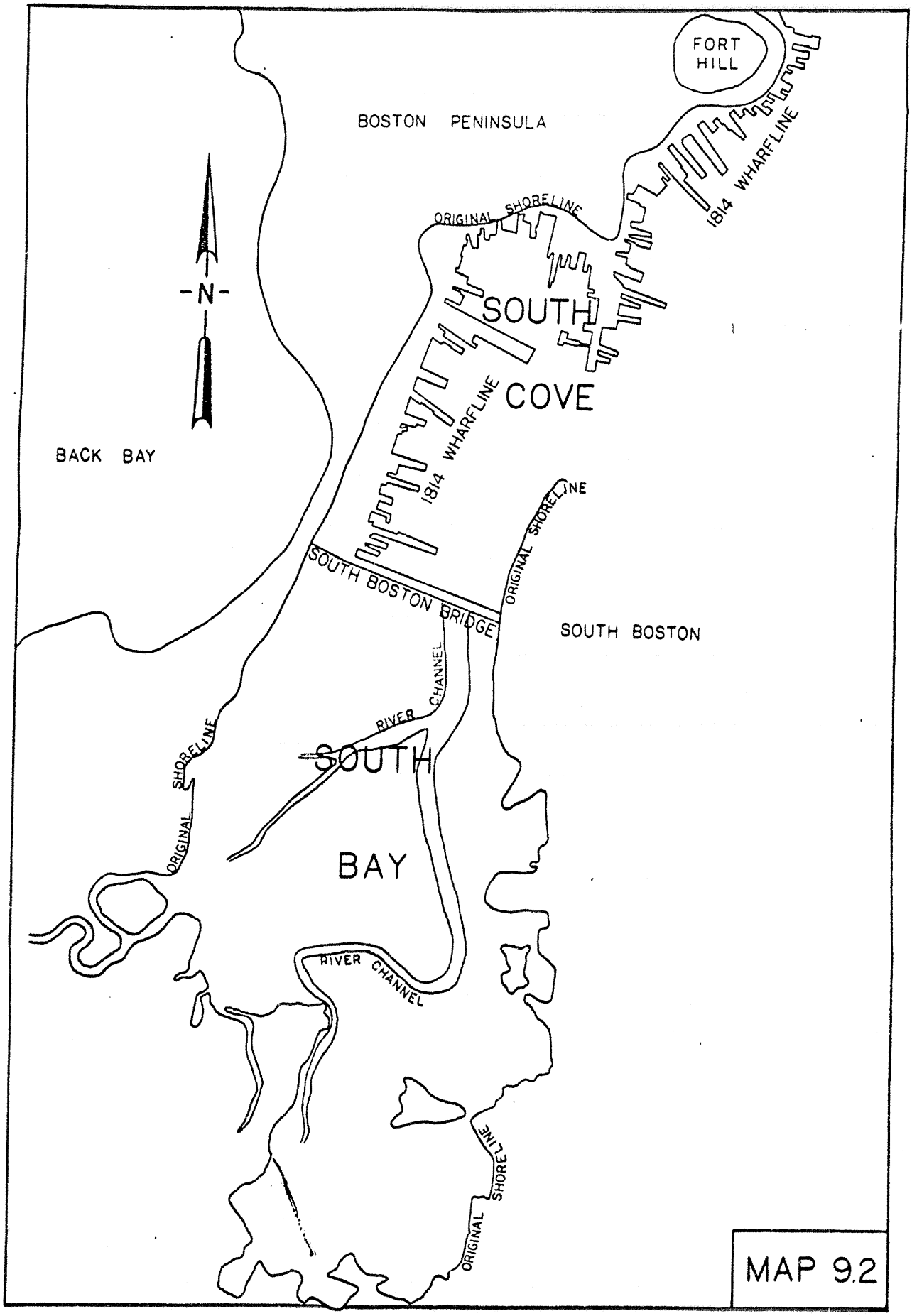
MAP 8.2

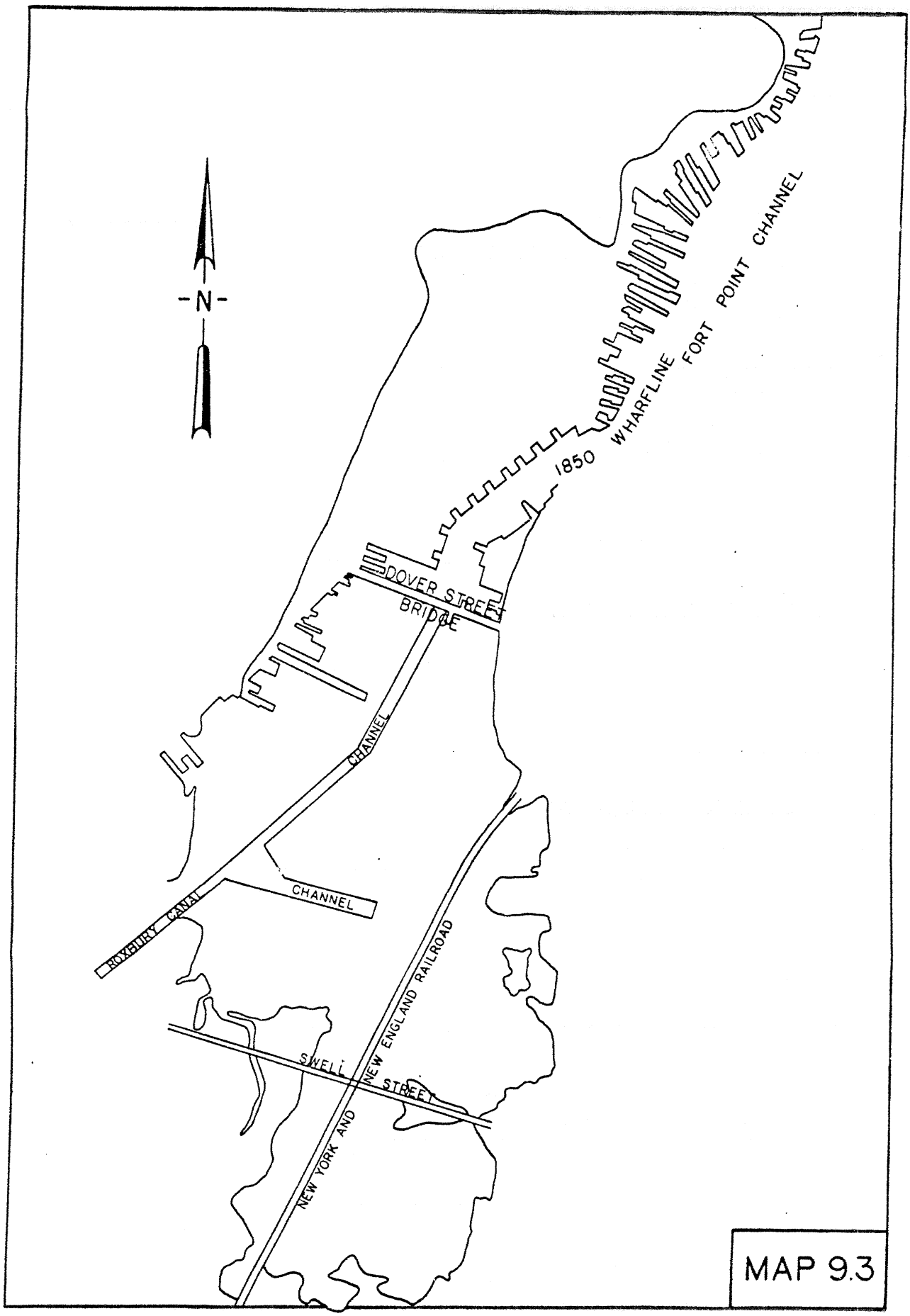

E
E
MAIN SHIP CHANNEL
HEAVY SEAWALL
SEAWALL 'B'
SEAWALL 'A'
DOCK
DOCK
SEAWALL 'C'
SEAWALL 'D'
F
SB6
SB7
SB2
SB3
A
LIGHT SEAWALL
SB2
SB1
SB4
SB5
BULKHEAD 'B'
BULKHEAD 'A'
PIER 4
PIER 3
PIER 2
PIER 1
MAIN SHIP CHANNEL
TEMPORARY CHANNEL
SEAWALL 'E'
E STREET EXTENSION
RESERVED CHANNEL
N
MAP 8.3

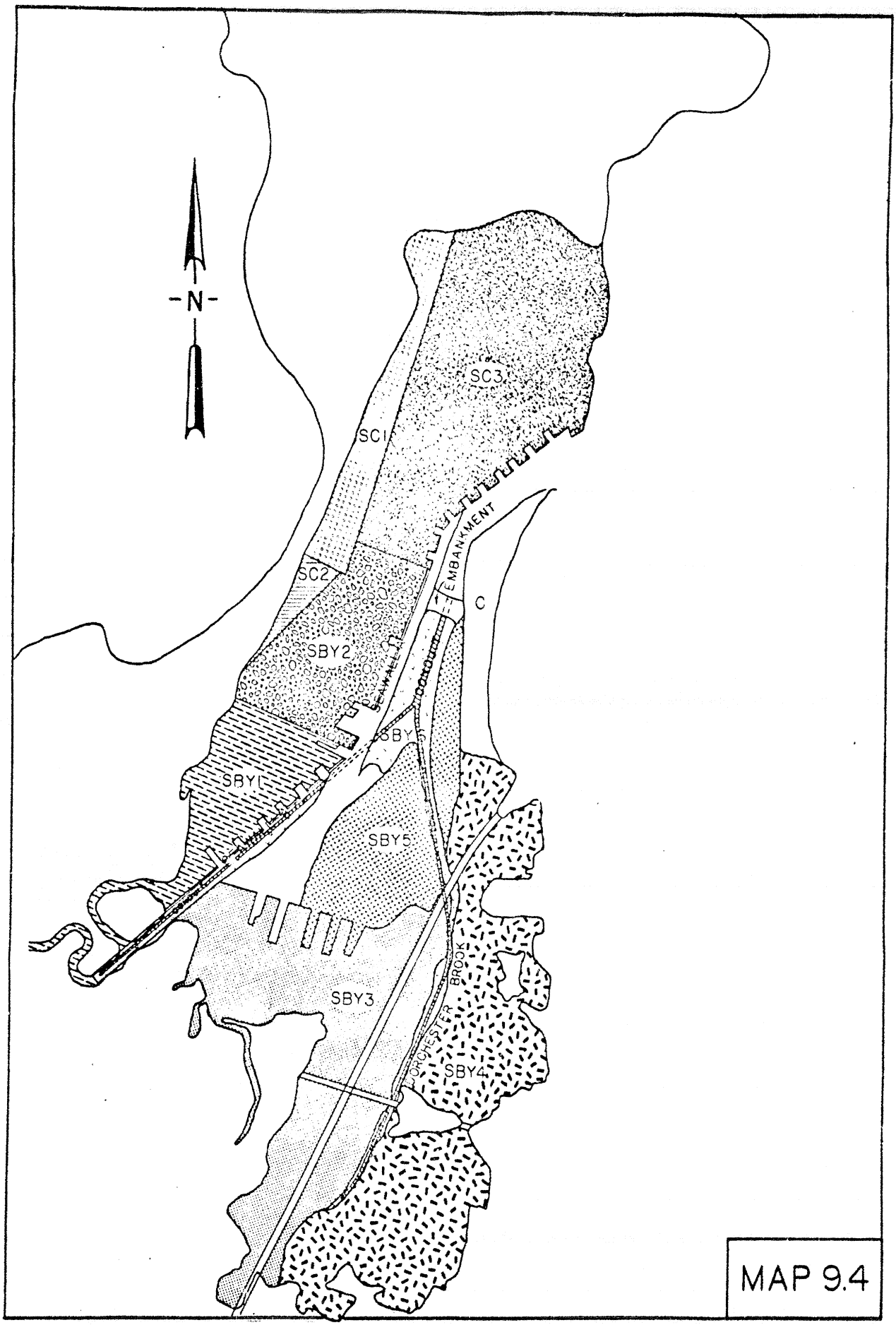

N
EMBANKMENT B
EMBANKMENT A
SB12
SB8
SB9
SEAWALL
RELOCATED RESERVED CHANNEL
SB11
SB10
PLEASURE
BAY
IRON PIER
PIER
HEAD

MAP 8.4


Frog Pond
Boston Common
Pub' Ga.
Park-St
TREMONT ST
ESSEX ST
SUMMER ST
CONGRESS ST
Office
Fire Sta
South Sta
Fort Point Channel
Police Sta
Fire Sta
INTERCHANGE
CONRAIL
Sta
Rotch Playground
Blackstone Square
Franklin Square
INTERCHANGE 15
FITZGERALD EXPRESSWAY
WEST FIRST ST
BROADWAY
Hoar Sch
W 7TH
South Boston
CONRAIL
DORCHESTER
OLD COLONY
Park
Shrine
SOUTHAMPTON
Fire Sta
INTERCHANGE
Andrew Square
COLUMBIA RD
BLVD
GERARD ST
NORFOLK
Playground
House
N
MAP 9.1


FORT HILL
BOSTON PENINSULA
1814 WHARFLINE
ORIGINAL SHORELINE
-N-
SOUTH COVE
BACK BAY
1814 WHARFLINE
ORIGINAL SHORELINE
SOUTH BOSTON BRIDGE
SOUTH BOSTON
RIVER CHANNEL
SHORELINE
ORIGINAL
SOUTH BAY
RIVER CHANNEL
SHORELINE
ORIGINAL
MAP 9.2


-N-
1850 WHARFLINE
FORT POINT CHANNEL
DOVER STREET BRIDGE
CHANNEL
CHANNEL
ROXBURY CANAL
NEW ENGLAND RAILROAD
SWELL
STREET
NEW YORK AND
MAP 9.3


N
SC3
SC1
SC2
EMBANKMENT
C
SBY2
SBY
SBY1
SBY5
SBY3
ORCHESTER BROOK
SBY4

MAP 9.4